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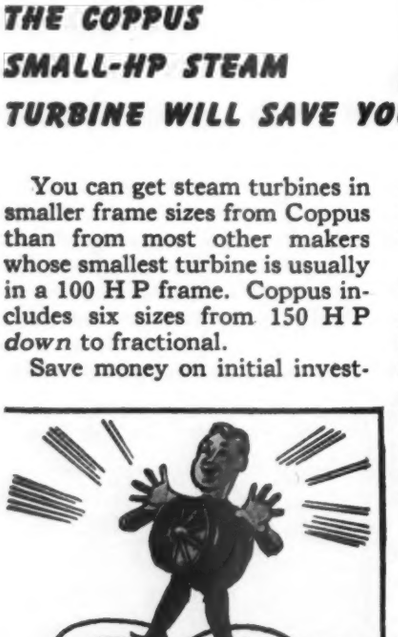

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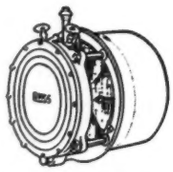

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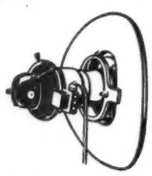

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ON THE COVER

OUR cover picture shows a tunnel that was driven through a snowslide to open a highway in Chile for travel. The road runs from Santiago to the Perez Caldera mill of Cia. Minera Disputada de Las Condes. The mill is at an altitude of 9,000 feet, while the mine, which produces copper, is 4,000 feet higher. This picture was taken by Enrique Fresno, an employee of Ingersoll-Rand Company, during a trip to the mine to service machinery. From the mill he had to make his way eight miles on skis to reach the mine. The photograph was a prize winner in our recent cover-photo contest.

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IN THIS ISSUE

NO one knows just how much iron ore there is in Brazil. Some writers have estimated that there is enough to supply the world for 400 years. We have been conservative in our leading article and said 100 years. The important point is that Brazil is making ready to take full advantage of its ore deposits by erecting a modern steel plant. Efforts towards this end have been expended for many years, but various obstacles were encountered. The chief stumbling block was the supposed lack of suitable coking coal. All sorts of substitutes were proposed, one man even suggesting the use of the husks of babassu nuts, which are plentiful. In the end, American technologists determined that Brazilian coal would make satisfactory coke.

•

VERY few of our articles are collaborative efforts. The one titled *Globes of Earth and Sky* falls in that category and the authors are both in the same family. In normal times Stephen A. Ionides is a consulting mining and chemical engineer in Denver. At present he is in the Army Signal Corps. Margaret L. Ionides is his daughter. This is not their first joint writing effort, as they are co-authors of the book *Stars and Men.*

•

HISTORY is replete with examples of men who were "ahead of their time." Many of them worked in the fields of science and mechanics and their discoveries were looked upon with suspicion and distrust. The rough path trod by inventors of some of our most important machines is pointed out in the article, *Inventors and Some Inventions.*

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Compressed Air Magazine

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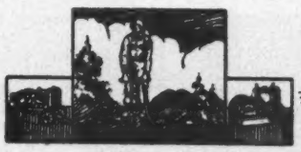

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Brazil's First Modern Steel Plant

C. H. Vivian

Moore-McCormack Lines Photos

ALTHOUGH Brazil has deposits of iron ore sufficient to supply the entire world for perhaps 100 years, the country has never had a modern steel plant. That deficiency is now being corrected by the erection of an integrated mill that will be completed early next year and that will go far towards making the South American republic virtually independent of imported iron and steel products for the first time in her history. The step is a very important one in Brazilian economy, and will have a highly ramified effect. By making iron and steel available at lower prices, it will greatly stimulate their use. It will lead to the establishment of factories for the manufacture of various iron and steel articles which are now obtainable only from abroad. It will provide rails at favorable prices for extending railroad lines, and this, in turn, will be of aid in the general development of the nation.

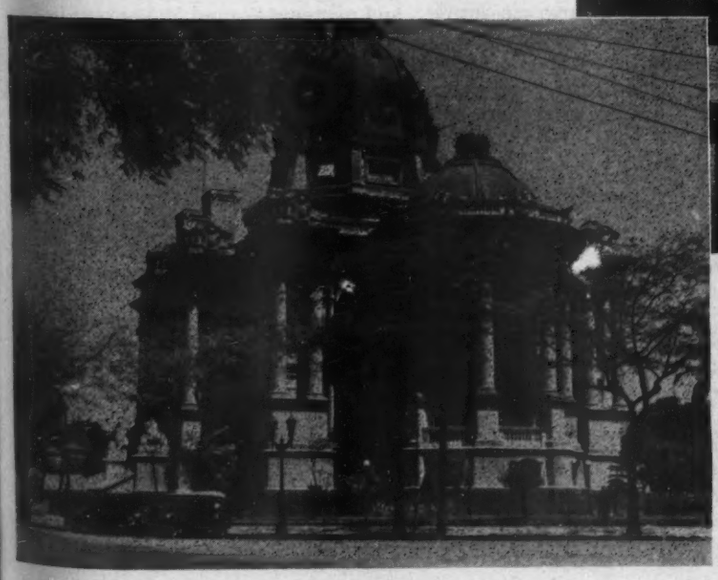
The new steel mill is being built by the Companhia Siderurgica Nacional (National Steel Company) at a cost of $60,000,000 of which $25,000,000 has been loaned by the Export-Import Bank of the United States and the remainder has been raised in Brazil. The undertaking has the active support of President Getulio Vargas, who has long sought to bring about a more thorough development of his country's vast mineral resources. The engineering for the project is being done by a United States firm, which also will direct the setting up of the equipment. For many months the Brazilian Steel Commission has had a group of specialists in this country and has maintained offices in New York and Cleveland. These men have been conferring with the engineers Arthur G. McKee & Company of Cleveland and placing orders for materials and machinery. This commission was headed for a time by Lieut. Col. Edmundo Macedo Soares e Silva, who previously had directed the studies in Brazil on which the present development is based. He returned to his native country a few months ago to superintend the construction and outfitting of the new mill. The commission has expended about $30,000,000 in the United States. To obviate delays in getting the plant ready for operation, priorities have been granted on all the structural materials and equipment required.

The mill will be located at Volta Redonda, in the State of Minas Geraes (General Minerals), about 90 miles from Rio de Janeiro and 220 miles from Sao

Paulo. These two principal industrial cities of Brazil will consume a considerable percentage of the plant's output, which will initially be about 300,000 tons of steel and 50,000 tons of pig iron a year. The iron ore, manganese, and limestone to supply the mill also will come from Minas Geraes deposits and will be shipped by rail. Coal, the other important raw material, will be obtained from mines in the State of Santa Catarina in the southern part of the country. It will be transported by railroad to the Port of Laguna and thence some 500 miles by water to either Angra dos Reis or Rio de Janeiro, both of which are connected by rail with the plant site.

The beginning of construction of the new mill represents the fruition of many years of effort by forward-looking Brazilians to capitalize upon the enormous mineral resources with which their land is endowed. Many seemingly insurmountable obstacles blocked their path, and perplexing problems had to be solved. It should be recorded to their credit that they persevered in the face of all these discouraging factors until the way was cleared and their objective reached. Some of these difficulties were of a political nature and some were physical. It has long been known that Brazil's iron deposits are the finest in existence, but until recently her coal was considered unsuitable for making the metallurgical coke that is required for large-scale steel production. For that reason the limited iron

Photo from American Brazilian Association, Inc.



Moore-McCormack Lines Photos

VIEWS IN RIO

Rio de Janeiro, capital of Brazil, is the largest city in the country and the second largest in South America, having a population in excess of 1,500,000. Its Portuguese discoverer sailed into the harbor in January, 1502, and because he thought it was the mouth of a river named it "River of January." Rio is architecturally a mixture of old and new buildings in which Portuguese, French, and Italian influences are evident. The harbor, which is big enough to accommodate the navies of the world, is dominated by Sugar Loaf, a conical peak that rises to a height of 1,212 feet.

WHERE PLANT IS RISING

The site of the new mill as it appeared soon after construction began. The Paraiba River runs along the base of the distant hills. The location of the new town of Volta Redonda (which means "river bend") is in the right foreground.

industry that has been carried on was based on the use of charcoal and imported coke, both of which are high in price. Until the present undertaking was projected it was believed that any steel industry that might be established would have to depend largely upon coke from abroad, and several plans based on that supposition were considered in recent years, only to be declared impracticable. Moreover, until of late there has not been a strong demand for iron and steel products in Brazil, and this lack of a potential market, augmented by the absence of adequate transport facilities, has discouraged investment of foreign capital in large steel plants.

The United States of Brazil is larger than our own nation and makes up almost half of South America, its extreme dimensions being 2,675 miles from north to south and 2,691 miles from east to west. It has a population of approximately 46,000,000, which is increasing at the rate of about 4 per cent annually. Brazil has long been primarily an agricultural country, but under the administration of President Vargas industries have undergone decided expansion, with especial emphasis on those based on mineral resources. The movement has been a nationalistic one, inspired by a desire to create an industrial economy capable of supplying the country's needs and employing Brazilian capital and labor. In line with this policy have been adopted new mining laws which virtually preclude foreign ownership or control of mines and industrial plants. This industrialization program began during the first World War, when Brazilians realized their great dependence upon imports and sought to lessen it. Considerable progress towards greater self-sufficiency has been made in the intervening years, but the nation still relies on foreign manufacturers for many articles that could be produced at home. The present conflict is already giving added stimulus to the movement, especially as regards a more effective utilization of the raw materials that are available for making iron and steel.

There is iron ore in every state in Brazil, but that in Minas Geraes is outstanding for its quantity, high iron content, and freedom from impurities. It is predominantly hematite, which is relatively easy to reduce; and the deposits constitute the greatest reserve of high-grade ferrous ore of which there is knowledge. They occur throughout an area measuring roughly 100x60 miles and extending southwestward from the Itabira do Matto Dentro district. Those at Itabira, which has often been described as a mountain of ore, are the best known. The ore bodies are in zones inclosed by mountain ridges of quartz-schist, gneiss, and granite. These zones are sometimes several miles in length and range up to a mile in width. Individual ore bodies are from 1,000 to 2,000 feet long and as much as several hundred feet wide. They are massive, compact deposits of hard, low-phosphorus hematite containing 55 to 65 per cent of iron, or some 10 per cent more than the Great Lakes deposits that furnish the bulk of the ore for our own iron and steel industry. At Itabira one ore body has been explored to a depth of more than 2,000 feet along the dip. It is estimated that there are approximately 1,500,000,000 tons of ore of this kind in the Itabira area.

These ore bodies are commonly overlain by from 20 to 50 feet of surficial masses of *canga*—hard cobbles and various-sized fragments of hematite cemented together by limonite (iron carbonate). Its value depends upon the quantity of hard hematite fragments present, but it is ordinarily relatively low in iron and high in phosphorus. In some places the *canga* has been so greatly decomposed by weathering that it can be readily mined with picks and shovels and has supplied material for several local furnace operations.

A third type of ore is *itabirite* or *jacutinga*, which consists of beds of hematite interspersed with some limonite and quartz. It is usually porous and friable and averages around 50 per cent iron and 30 per cent silica. It is frequently gold-bearing, and in some areas the concentration of gold is such as to form deposits worth working. It was in locations like these that the ancients mined gold with slave labor, and streams crossing the formations have yielded considerable placer gold. Brazil's greatest and oldest gold mine, the Morro Velho of the St. John del Rey Gold Mining Company is in such a region. It has been worked since 1834 and has reached a depth of more than 8,000 feet below the surface.

The Minas Geraes ores have been mined to some extent since 1806, and since then numerous small furnaces have been built to make pig iron. Compared with the amount of ore that remains, however, the quantity that has been taken is so insignificant that it can be said that the surface has hardly been scratched. The

largest development is at Monlevade, which is named for a Belgian who established works there in 1860. In 1934 this plant was expanded, and its 1939 output, together with that of another one established at Sabara by the same company (Cia Siderurgica Belgo Mineira), amounted to 72,452 tons of pig iron and 59,155 tons of steel of which 40,787 tons represented rolled products. Three other concerns turned out a total of 51,572 tons of steel in 1939, including 47,561 tons of rolled material. In addition, nine companies were engaged in making pig iron, of which the national output was 160,067 tons.

Although there has been a pronounced increase in domestic production, Brazil was able to supply only about 30 per cent of her 1939 consumption of 440,000 tons of iron and steel and products manufactured from these metals. The remainder was imported, chiefly from Germany, Belgium, and England. The prices paid for them by the Brazilian consumers were high, averaging about twice those prevailing in the United States of America for equivalent items. The high prices are attributable partly to duties levied on steel products by the Brazilian Government and partly to freight and insurance charges and the difficulty of obtaining exchange. Largely as a result of the comparatively high cost of steel, Brazil has used relatively little of it for construction purposes. Instead, the country has turned to concrete, and has developed a technique for applying it to office and factory buildings and other large structures, some of which are 25 stories high. Even concrete calls for some steel for reinforcement, but this is usually in the form of simple shapes and small sections which have been turned out for the most part in Brazilian mills.

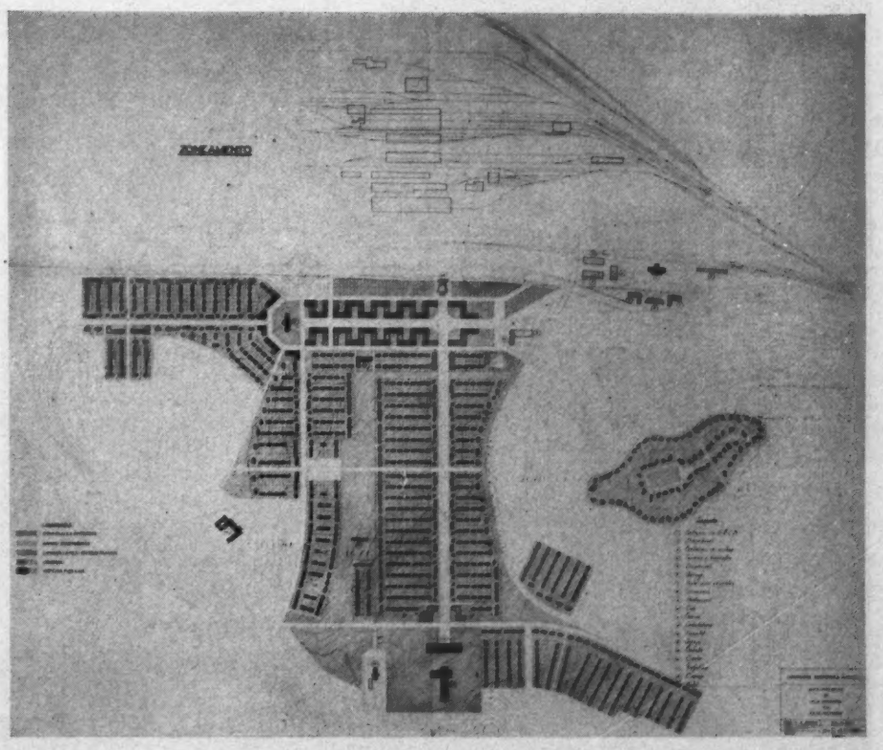
Despite the marked increase in the demand for steel and steel products in the past decade, Brazil consumes annually only about 20 pounds per capita, as compared with 135 pounds in Italy, 320 in France, 550 in Great Britain and Germany, and 850 in the U.S.A. It is expected that the establishment of the new steel mill will make those products available at a price that will soon double their per capita use.

It is impossible to set down here more than the highlights of the efforts Brazil made to bring about the development of her iron-ore resources prior to the acceptance of the plan now being carried out. President Vargas assigned the problem to Colonel Soares, a competent metallurgist, and the latter did a thorough job. After he had informed himself of every phase of the matter at home, he went abroad to study modern steel-making practices. At that time he favored establishing a steel mill at Victoria, a port north of Rio de Janeiro that is connected with the Itabira section by a narrow-gauge (1-meter) railroad. He failed to interest British capital in this project partly because large expenditures would have been necessary to put the road in shape to transport the large quantities of raw materials required and also because of the old bugaboo of inadequate Brazilian coal.

In 1939 the subject became active, and the possibility of obtaining help from the United States was discussed in conversations between Brazilian Foreign Minister Oswaldo D. Aranha and President Roosevelt while the latter was in Brazil. As an outgrowth of these conferences, a large American steel company became interested to the point of sending a committee of seven of its technical men to Brazil. They spent three months on the mission and then tendered a report to the corporation. Although newspaper accounts at the time indicated that the committee favored entering into a partnership with Brazil to erect a mill, the final decision was adverse.

President Vargas then appointed a 6-man Commission for Metallurgical Planning which included Colonel Soares. The commission employed Arthur G. McKee & Company, which has for many years done consulting engineering work for American steel companies, to check and review a report prepared by Colonel Soares and to compile rough estimates of the cost of constructing an adequate steel plant. Vice-president William A. Haven, in charge of steel-mill operations of the McKee firm, elected to handle the job personally and spent a number of months in Brazil. His report, tendered during the summer of 1940, confirmed in every essential respect the findings of Colonel Soares, and in August the Brazilian commission came to this country and negotiated successfully with the Export-Import Bank. A loan of $20,000,000 was granted and subsequently increased to $25,000,000. The remainder of the required funds, amounting to some $35,000,000, was raised in Brazil by issuing preferred and common stock in the National Steel Company. The Brazilian Government bought the entire issue of preferred stock. As soon as the financial arrangements had been completed, bids were taken covering the engineering services in connection with the new mill, including the preparation of plans and the supervision of construction. The award went to the McKee organization.

Investigations in connection with the

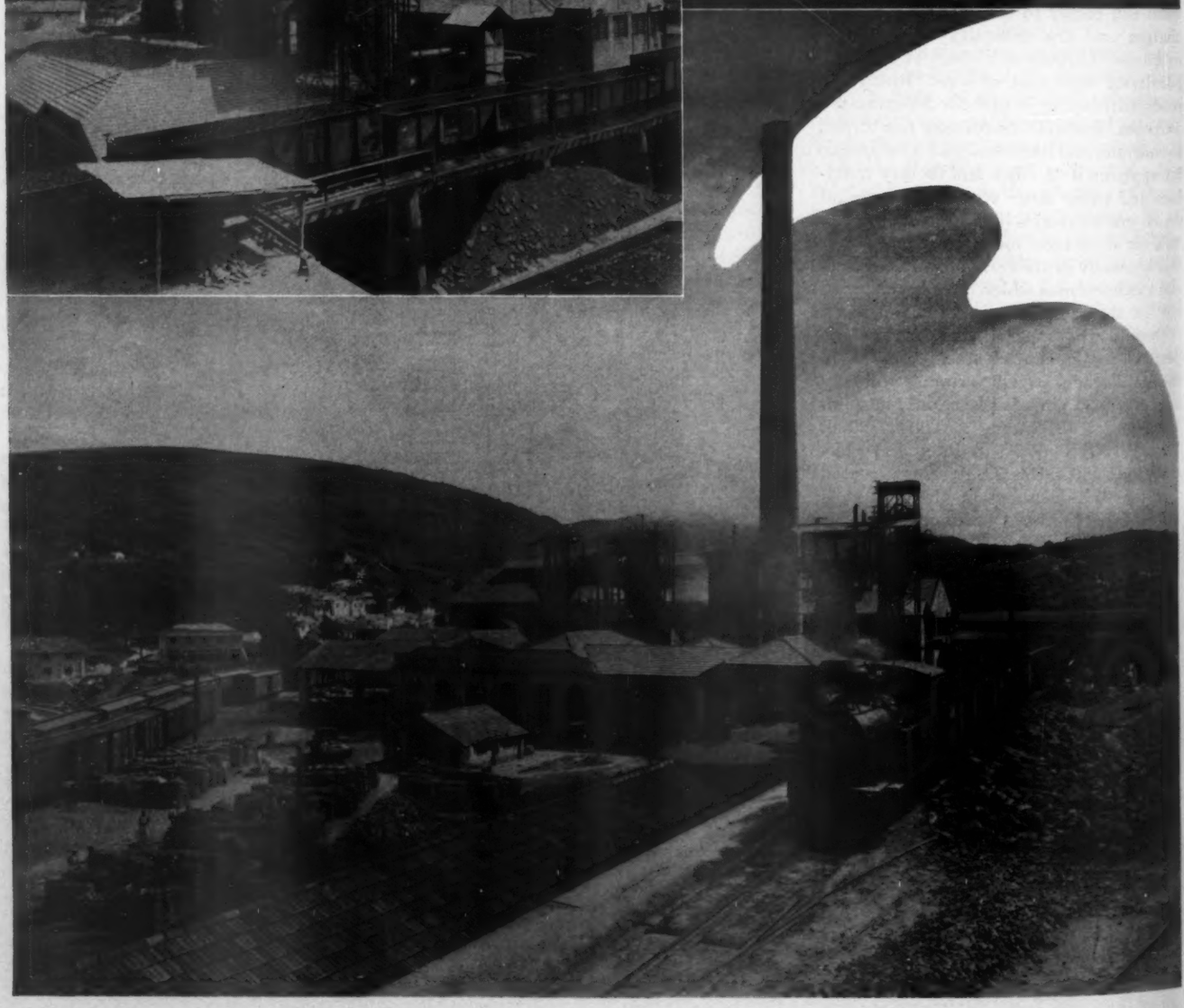


LAYOUT OF NEW TOWN

By the time the new steel mill is in operation, the new town of Volta Redonda, which is being built on sloping ground rising from the Paraiba River, will be ready to house the 10,000 persons the industry will attract. At the top of the drawing is a section of the steel mill, which will be 3 miles in extent. President Vargas of Brazil is personally interested in making the community a model one as regards cleanliness, sanitation, comfort, and appearance. The 1,200 homes are being constructed of concrete blocks and are of several standard types, each designed to accommodate a family of a given size. Public buildings will include churches, schools, stores, a hotel, restaurant, hospital, club, day nursery, motion-picture theater, and numerous other structures to minister to the needs and recreation of the population. Streets will be wide, houses will be located according to a definite pattern, and there will be ample park areas. The plant will require 4,000 workers at the outset, and this number will be gradually increased as steel production expands to meet the country's growing consumption.

"USINA" GORCEIX

The third largest pig-iron producer in Brazil is Cia Ferro Brasileira, which was organized in 1931. At Gorceix it operates three 40-ton blast furnaces fired with charcoal. Shown here are the Gorceix works and the three single-stage compressors that furnish air for blowing the blast furnaces. In addition to pig iron, the company makes iron and bronze castings. Its output of pig iron in 1939 was 15,395 tons.



iron-ore development brought out one significant point that considerably brightened the prospects for manufacturing iron and steel at low cost. This was the discovery that a suitable grade of metallurgical coke could, contrary to long-held convictions, be made from Brazilian coal. This fact was confirmed by tests run at the Battelle Memorial Institute in Columbus, Ohio. The raw coal has an ash content of around 25 per cent, as compared with 10 per cent for the better American and European coking coals, and runs high in sulphur. However, the latter occurs in the form of pyrites and can be removed by washing. The fines from the washery (under ½ inch) will be used for coke-making, as it has been determined that their ash content will be comparatively low (14 to 18 per cent). The other sizes delivered by the washery (from ½ inch to 2 inches) can be utilized for steam-raising purposes. High-ash coals are serving successfully in steel mills in Japan and also at the Tata Iron & Steel Company works in India, and these are reputed to produce steel at a lower cost than plants anywhere else in the world.

One apparent drawback of the Brazilian coal is the physical weakness of the coke obtained from it, a factor that, it was believed, would render it incapable of supporting the heavy load that would be imposed upon it in large blast furnaces. However, tests subsequently made indicate that the coke will have ample strength. The Santa Catarina mines from which the coal will come are now producing about 150,000 tons a year, and their capacity is around 300,000 tons. The output can be easily increased by improving the railroad that will deliver it at Laguna and by augmenting the dock facilities at the latter point. A survey conducted by Dr. Joaquim Lisboa in 1939 estimates the coal reserves at 1,000,000,000 tons. As the requirements of the new mill will be only 800,000 tons a year at the outset, an ample supply is insured for generations to come.

The iron ore for the plant will be obtained from deposits between Lafayete and Bello Horizonte. They are adjacent to the main broad-gauge line of the Central Railroad of Brazil and 240 miles away from the mill site. Hard hematite, *canga*, and *itabirite* grades of ore are available. Their iron content ranges from 58 to 66 per cent, their phosphorus from 0.05 to 0.15 per cent, and their silica from 1.30 to 6 per cent. The richness of these ores and the small amount of gangue (non-metalliferrous) material they contain will tend to counteract the disadvantages of expensive, high-ash fuel. In fact, it is expected that the quantity of slag-forming materials in the blast furnaces will be less than that in many other steel-producing sections of the world, among them the Birmingham district of the United States. The initial annual consumption of ore is placed at 750,000 tons. The reserves in the San Francisco and Doce valleys, the source of the supply, are estimated at 11,000,000,000 tons. As the ore lies at or close to the surface, it will be mined by inexpensive open-pit methods. Of the other principal raw materials that will be needed, high-grade deposits of manganese, limestone, and dolomitic limestone are available, the latter two close to the mill site and the manganese about 220 miles distant. The fact that all of them contain almost the highest possible amounts of the respective minerals desired will be important from the standpoint of reducing transportation costs.

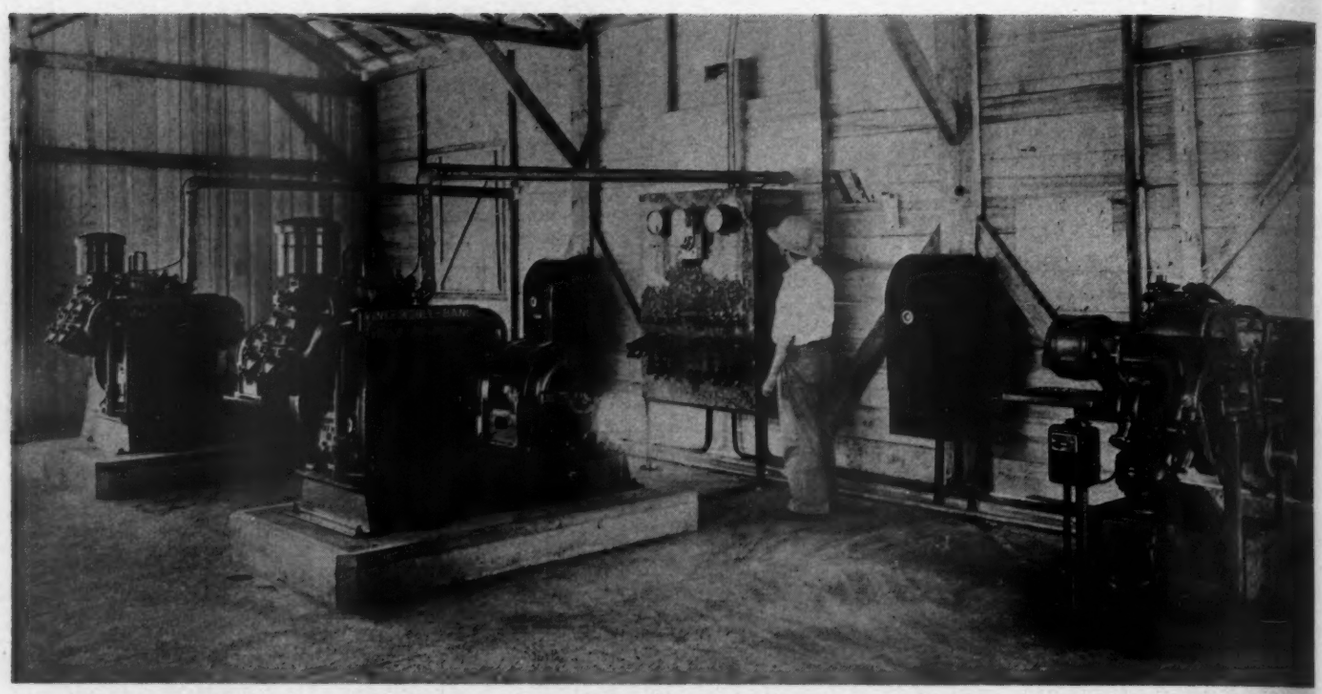
MONLEVADE

In 1860, a Belgian named Monlevade built the first rolling mill in Brazil, and in 1921 the works that he started were incorporated in the Cia Siderurgica Belgo Mineira. The company constructed new plants at Monlevade and nearby Sabara in 1934, embarking on an expansion program that is still underway. This picture shows the property at Monlevade, which was literally carved out of the jungle and represents four years of work on the part of Brazilian, Belgian, and Luxembourg engineers. The present equipment consists of three 100-ton blast furnaces that use charcoal for fuel, and two Siemens-Martin open-hearth furnaces with an annual capacity of 55,000 tons of steel. This company produces nearly half the iron and steel now turned out in Brazil.

In selecting a site for the plant, six possible places were investigated. A mountain range, the Serra do Mar, runs parallel to the coast and between the iron-ore deposits and the ports through which the coal will have to be delivered. This range is roughly 1,000 miles long, 1,500 feet high, and more than 100 miles wide. Because there are no watercourses for the railroads to follow, most of those that cross this upland area necessarily have high grades, many curves, and a number of tunnels. A considerable section of the track is of narrow gauge. These conditions naturally impose transport problems. The location at Volta Redonda was determined upon after the commission had computed the relative costs of assembling raw materials at and distributing finished products from the various points under consideration.

Volta Redonda is on the western side of the Serra do Mar and is served by a main line of the Central Railroad of Brazil. The plant site is comparatively level despite the generally hilly nature of the region. The mill is rising along one side of the Paraiba River, which will provide an ample supply of water, and is on high enough ground so that the danger of flood damage is remote. The plant will have an over-all length of about 3 miles. On the side of the valley slope above it there is being built the model town of Volta Redonda with facilities for housing 10,000 persons. As the steel mill will employ about 4,000 workers, it is expected that the community will be fully occupied from the start. President Vargas is taking a personal interest in making it a show place, and it is being constructed accordingly. As an accompanying illustration shows, it has been laid out with curving streets, wide esplanades and park areas, and careful attention will be paid to landscaping. The town will be provided with electricity, gas, and treated water. Public buildings will include schools, a 100-room hotel, church, motion-picture theater, public hall, club, restaurant, and day nursery. The houses, which will be built of concrete blocks, will be of several types, depending upon the number of persons to be accommodated. A typical home for a small family will consist of a living room, kitchen, bathroom, two bedrooms, and two porches. The hotel will include a number of apartments, each with its own veranda. Dwellings erected by individuals must conform to the company's plans.

Although the steel plant will initially produce only a relatively small tonnage, it has been designed so that its capacity



COMPRESSED AIR FOR CONSTRUCTION

The two Ingersoll-Rand Motorcompressors at the left supply air for quarrying stone for concrete aggregates and for excavating at the steel-mill site. At the right is an air-operated grinder for resharpening the Jackbits used in the drilling operations. Other Ingersoll-Rand equipment installed in the plant includes two turboblowers, each of which will supply 75,000 cfm. of air at 30 pounds pressure for blast-furnace blowing; four surface condensers, which will serve the steam turbines that will operate the blast-furnace blowers and the turbogenerators; and boiler-feed pumps.

can be readily increased. Because it is the desire to manufacture large rails, shapes, and plates from the beginning, the cost of the blooming mill, rail, and structural mills will be high when figured on a unit-production basis, but the capital charges will decrease as output grows. In view of the fact that only a small quantity of rolled products will be turned out at first, the use of continuous rolling processes were not considered justified, save for the sheet and tinplate mills. All others will operate on the reversing principle.

One blast furnace rated at 1,000 tons of pig iron daily is now being constructed and provisions are being made for adding three more as they are needed. The single furnace will furnish metal for four open-hearth steel furnaces, which will supply ingots for the various rolling mills. The latter furnaces will be of the basic type and will be fed no scrap steel other than that created at the plant. The ingots will go through a blooming mill, which will be arranged to deliver blooms direct to the heavy rolling mills or slabs to a yard, where they will be held for reheating and subsequent use in the smaller mills, as desired. Rolling equipment will include a rail and structural mill, a 72-inch plate mill, a 50-inch hot-strip mill, and a cold-strip mill that can produce strip or sheet or tin plate. Complete galvanizing and tin-plating equipment will be installed. The rolling mills will be capable of handling the output of three blast furnaces, so no expansion of that department will be necessary for a long time. Maximum sizes of the various products will be: rails, 120 pounds per yard; shapes, 24 inches; rounds, 6 inches; billets, 4x4 inches; plates, 1x60 inches. Sheets and tin plate will be of normal gauges. For the present, no facilities will be provided for making wire, barbed wire, or tubes.

The following table shows a breakdown of the proposed initial tonnage of the new plant and lists Brazils average annual steel imports in recent years:

	New Plant	Imports 1930-38
Structurals	25,000	13,700
Flats, rounds	50,000	36,000
Rails, etc.,	90,000	72,000
Barbed wire	——	19,100
Wire	——	24,500
Tubes	——	25,700
Plates	60,000	37,000
Tin plate	50,000	33,800
Pig iron	50,000	——
Total steel	295,000	261,800
Total iron	50,000	——

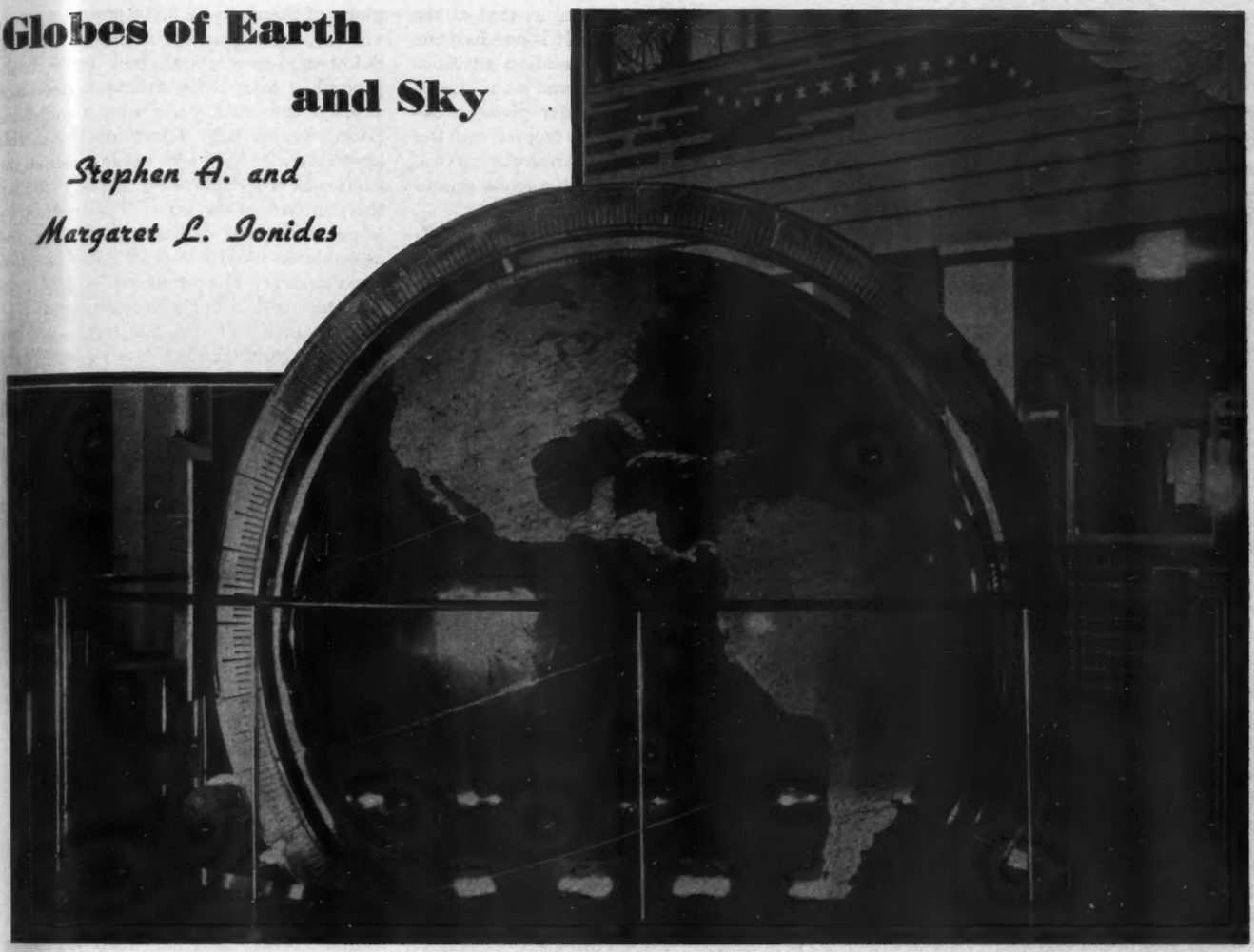
The coke plant will consist of one battery of 55 ovens and provision will be made for adding three more batteries. It will supply all the needs of the mill, as well as a small yearly surplus of foundry coke for sale. The powerhouse will utilize blast-furnace and coke-oven gas and will also have some coal-fired boilers. Furthermore, connections will be made for bringing in outside power in case it is required. The open-hearth furnaces will be fired with a mixture of blast-furnace and coke-oven gases. In addition to the facilities for manufacturing iron and steel, the plant will include machine shops, a forge shop, and locomotive repair shops.

Brazilian wages are very favorable to low-cost steel production, being about ten cents an hour for unskilled labor and fifteen cents an hour for skilled labor. Railroad freight charges are less than those in the United States. Because of these factors and the richness and easy workability of the ore, the over-all production costs should compare well with those in the world's foremost steel centers despite the low-grade fuel and the relatively long haul of most of the raw materials.

The mill's initial annual capacity of 300,000 tons will be just about sufficient to replace the tonnage of steel products that has been imported into the country for some years. The trend towards a greater per capita steel consumption and the natural growth in population are expected to increase the output to 500,000 or 600,000 tons by 1950. Aside from the exploitation of the hematite iron deposits that will supply the plant with ore, 1,500,000 tons will be shipped annually to Great Britain and the United States under the terms of a recent agreement. This ore will be mined in the Itabira section and will be transported to Victoria by railroad for transfer to ships. A special conveyor belt that can load four vessels simultaneously and handle 7,000 tons a day has been constructed at that port. The agreement also provides that funds be advanced for improving the railroad line so that it can better carry the heavy shipments.

Globes of Earth and Sky

Stephen A. and Margaret L. Ionides



PAN AMERICAN'S GLOBE

This 10-foot sphere greets travelers at the international terminal of Pan American Airways at Miami, Fla. It shows the distribution of land and water, ocean currents, heights of mountains, and depths of seas.

THE International Airport of the Pan American Airways in Miami, Fla., is built around a tremendous globe. It is 10 feet in diameter, more than 31 feet in circumference, and its axis is ordinarily tilted to the pole of the heavens. On the surface of this massive sphere are pictured the continents and oceans, and around it a single line—completing almost the great circle—shows how Pan American comes close to "circumaviating" the earth.

Most people know little about the ordinary globes they see or buy, therefore the one at Pan American fills them with wonder. But then it is a remarkable gadget. At first sight it seems to occupy the room, being centrally located; but there are ticket offices tucked away in the background. Above it, on the ceiling and mixed up with portraits of early flying machines, the constellations of the zodiac look down.

In this combination of earth and sky, the Pan American architects have closely followed the builders of King Solomon's temple—the world's oldest globular tradition. For we read in the Bible that Hiram, the metal worker of Tyre placed before it two pillars, and the two pommels of the chapiters that were on the top of the two pillars; and the two wreaths to cover the two pommels . . . and four hundred pomegranates for the two wreaths, even two rows of pomegranates for one wreath, to cover the two pommels of the chapiters that were upon the pillars. Masonic tradition tells that the two pommels were globes, one a terrestrial globe and the other a celestial globe. The massive Pan American pommel needs no wreaths or pomegranates; it is perfection in itself. But behind that perfection lies the full story of astronomy, mathematics, geography, and history.

Most of us who purchase globes today have only the vaguest ideas about them. "Aren't they all the same?" men have been known to ask; and women, buying for their husbands or sons, are no better informed. "This globe has all sorts of extra things," they may explain; "it has a slanting line around the middle and a figure-eight doohinkus." The slanting line is one inexactitude that some globe-makers persist in retaining. Actually, it represents the ecliptic—the apparent path of the sun in its yearly travels to the north and south among the stars. On the other hand, the tropics, between which this strangely erratic line vibrates, are necessary to our knowledge of the earth. On every spot between them the sun will at some time of the year shine vertically. Likewise, the arctic and antarctic circles should be marked, since they designate the borders of the land of the midnight sun. All these phenomena are visible from the earth's surface. In short, the sun, being vertically over many places in the course of each day's route, does not follow the stray belt that is outlined on certain globes.

Then there is the figure-eight doohinkus commonly pictured in the Pacific Ocean. Its very geometrical shape itself suggests that it does not really belong on our thoroughly ungeometrical earth. The Bellman in the *Hunting of the Snark* bought a geometrical map of which his crew approved but which was of dubious value because it represented the sea without the least vestige of land. If it was worthless, then the Pacific design has still less reason for

being. However, it has been dignified by a name. Allow us to present Miss Analemma. On request she will tell you the distance of the sun from the equator, and also how fast or how slow he is by your watch on any day of the year—all most valuable and important bits of information. But if "misplaced matter" is the dictionary's definition of "dirt," then it is also the definition for Miss Analemma. From time to time other anomalies appear on globes. The zodiac signs, delightful symbols, have a habit of ornamenting the stands where they really have no right to be. On celestial globes or overhead, as in the Pan American building, they are invaluable, instructive, and in place. But on terrestrial globes they are, literally, out of their sphere.

If a globe is to be a true representation of the earth, it should be fixed with its axis pointing to the north—the Pole Star—and at an angle equal to the latitude of the town where it resides. Its locale should, of course, be on top of the sphere. A good globe is adjustable, but many are made stationary at an angle of 23½°. This would be a permissible position in the case of the arctic or antarctic circles, but it is not a suitable angle for globes in Chicago, London, or the Straits of Magellan. The angle is the same as that of the obliquity of the ecliptic. It is one-half the difference between the meridian altitudes of the sun at midwinter and at midsummer. It is also the angular distance between the equator and the tropics, and the radius of the arctic and antarctic circles. It is not the angle at which a globe should be tipped.

The Pan American globe has an electrical rotation of its own; the household globe turns too, more slowly no doubt and without man-made gadgets, because it is on the surface of a rotating earth. True, the axis of the latter sphere is some few thousand miles away from the axis of the earth, but this discrepancy is very slight when compared with the 93,000,000 miles between earth and sun. So the little globe may, fairly, be said to represent the actual motion of the earth. In fact, the similarity is so complete that if you take a globe out into the sun and set it at the appropriate angle you will find day and night upon it. Further, at any sunlit time, the line on the western side will show where the sun is rising and the shadow line on the eastern side will show where the sun is setting.

A properly adjusted terrestrial globe as we know it today is, accordingly, a true portrait of the earth. Between it and the globe of Solomon lie 3,000 years of observation, mathematics, and adventure. Solomon's geographer had little background of knowledge except horizon and sky. A thousand years later a foot-loose friend was to help determine the earth's size; study of the stars made possible the divisions; and exploration led men to map the contours of the land. Fortunately we know something of Solomon's globe and are able to illustrate it because his close contemporary Homer described the then-known world in fairly precise terms.

Plato said that the earth moved, but Aristotle insisted that it was stationary (to the subsequent bewilderment of two milleniums). Still, the latter also believed that it was a sphere and, like a good philosopher, gave his reasons, which were all easily deducible from close observations of earth, horizon, and sky, and were as follows:

> All bodies tend to congregate at a common center, like snow into balls, or men into towns.
>
> Only a sphere will cast a circular shadow under all conditions. During an eclipse of the moon we see the shadow of the earth pass across the moon's surface, and it is always the circular shadow of a great ball.
>
> We see a shift in the range of horizon of the stars, and as we travel from north to south new constellations become visible. This would not be possible unless the earth were a sphere.

Strabo, who lived at the time of Christ, gave further proof that the earth was round. "For," said he, "from a distance I can see the glow of the top of the lighthouse in Alexandria; whereas the lights at the bottom are visible only when I am near. Why should we build our beacons on the top of pinnacles unless the surface of the earth is a sphere?"

With celestial globes the story is entirely different. Visibility, which is so limited on the surface of the earth, is far less restricted to one watching the skies. An observer on the equator can see all the stars in the heavens; but as he goes northward, a small circle in the south pole of the heavens will be invisible to him (its center at the pole itself—its radius equal to his latitude north). Thus at Latitude 45° a man may view three-quarters of the sky; at the North Pole one-half.

The first sky globe (after Solomon's) of which we have any description was made by Eudoxus of Cnidus whose catalogue of constellations was used by Aratus in his oft-quoted star poem. That globe has vanished, but a similar one of unknown origin, now known as the Atlante Farnese, is extant. The stars themselves are unidentified, but 47 constellations were once visible on its surface. Around the 24-inch diameter the equator is drawn, four other parallels, and four meridians. The ball is stationary, and rests on the shoulders of a kneeling Atlas. If its sculptor had been a close observer of the sky, then its date of

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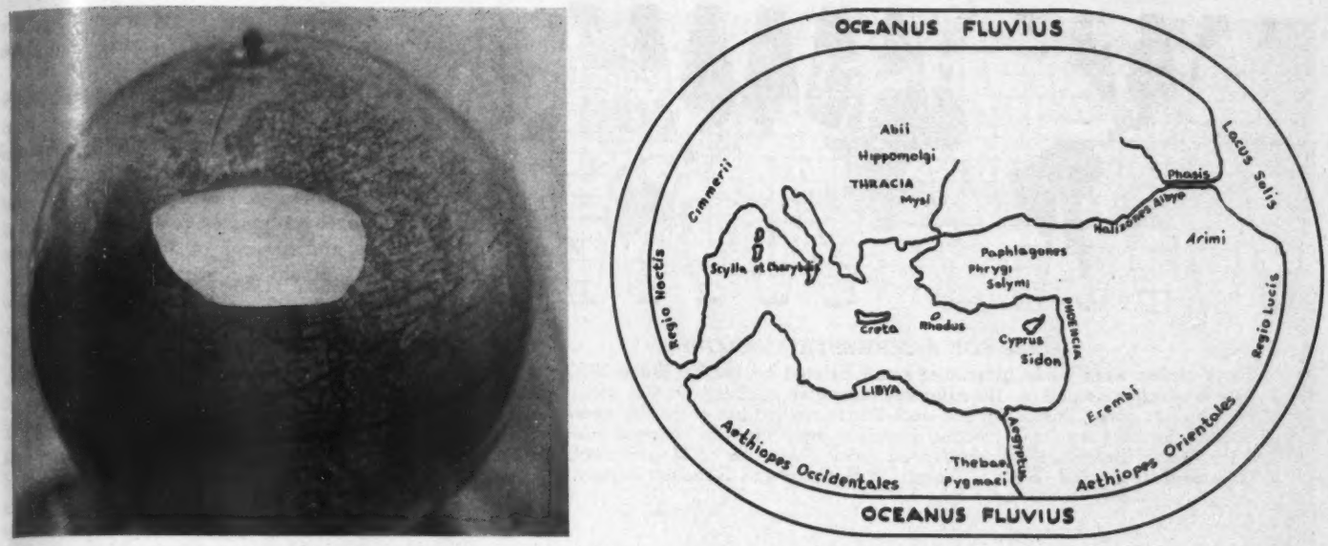
FAMOUS SIXTEENTH-CENTURY DUTCH MAP MAKERS

The title page from one of the maps of Gerardus Mercator and Judocus Hondius, showing the cartographers at work in their studio. Mercator was the most famous map maker of his time, and in 1541 he issued a celebrated terrestrial globe and followed it in 1551 with a celestial globe. In 1554 he produced a map of Europe in six sheets. All his charts were engraved on copper and lettered in Latin. Mercator himself adopted a Latinized form of his name, which was Gerhard Kremer. Prior to his death, Mercator sold his map plates to Hondius, who made many copies from them.



HOMER'S EARTH

The famous Greek poet, who lived about 1,000 B.C., visualized the earth as shown in the drawing, which is an adaptation of an illustration accompanying an article by John Murray in the Scottish Geographical Magazine for November, 1893. It will be noted that some of the place names are retained to this day. The photograph, in which Homer's earth is superimposed upon a modern globe, shows how little of the world he knew.

origin might be about 300 B.C., judging from the position of the spring equinox among the constellations. But he was probably copying from old records, or from Eudoxus, and may have lived a full century after the time of the heavens which he portrayed. Archimedes, the famous Sicilian who discovered specific gravity in his bathtub, is said to have made a mechanical device of globes with which the relative revolutions of the earth, sun, and moon, could be shown. If this is true (and we have Cicero's word for it) he was the first man to anticipate our modern orreries and the great planetariums that are their outgrowth.

Throughout the time when astrologers were prohibited (and consequently flourished) in Rome, the little spheres of the sky had great vogue. One of these may be seen today in the Metropolitan Museum in New York City. But celestial and terrestrial globes alike were soon to become things of the past. With the rise of the Middle Ages, these wonderful little balls were pricked, deflated like balloons. The fanatics of the church announced that the earth was the shape of a Shrove Tuesday pancake, for if it were spherical there could be no biblical cosmology. "In heaven's name which way is up, and where the hell is down?" But there were men who loved the world and the sky. In 900 A.D. we find Gerbert (scholarly magician and humorous pope) manufacturing celestial globes for his friends in exchange for copies of Latin songs. Ptolemy was translated into Latin in the middle of the eleventh century. The monastic documents were Latin translations of Arabic translations of Syriac translations of originals. Roger Bacon, perusing them carefully, decided that the earth must be a sphere. He used Aristotle's own arguments and with their aid convinced the scientists of his day.

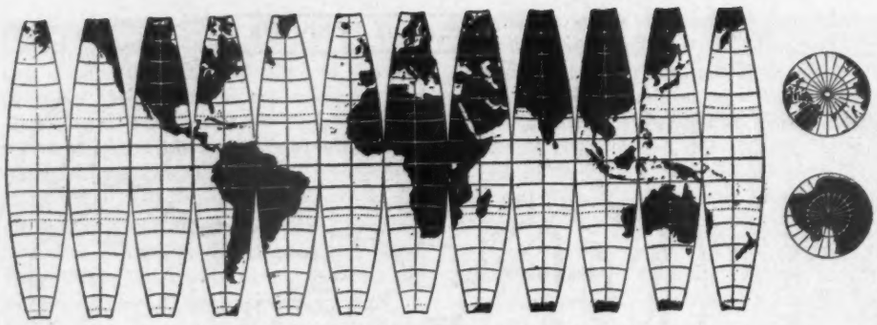
In time knowledge spread. It is true that Columbus was the first man to set out in order to prove that the world was round; but in the year he made his first journey, Martin Behaim of Nuremberg produced a terrestrial globe. This is the oldest European globe in existence, and as such deserves attention. It is interesting to note that the misplaced ecliptic appears on its surface. Behaim's sphere was a very remarkable endeavor for his day, and it was a work of art as well as of science. On its parchment cover are 1,100 place names, more than 100 miniatures, flags, coats of arms, animals, etc. With tender pride he called the globe his "earth-apple," which, after all, is much the same word as "pommel."

With the explorations of Columbus and his followers—Magellan, Drake, and all their fellow sailors of fortune who went east and west around the newly charted sphere—the demand for globes grew. Unicorns argent and lions rampant, which had ranged over the unknown and vacant sections, gave way to geographical information. Only some of the celestial attributes were left—the ecliptic and Miss Analemma, who first appeared about 1750 and in her present form about 1800. But, for the most part, globes were becoming more and more accurate. In the sixteenth century, when the art of printing—hardly 100 years old then—was called into the service, the business of globe-making was a flourishing one.

All terrestrial spheres outline the continents, most show the equator, meridians of longitude, parallels of latitude, and usually the tropic lines and the arctic zones. Beyond these essentials, the choice of detail depends solely upon the nature of the globe. As it is designed primarily to demonstrate features on a world-wide scale, it may indicate the distribution of land and water, ocean currents, heights of mountains, and depths of seas. If the features pictured are practically permanent, the globe is apt to be timely for several hundred years; but if it gives political divisions that are apt to change without notice, it may be out of date before it is put on sale. For this reason some manufacturers send out little strips which can be pasted on the surface.

However, all information should be generalized. Most of us cannot have a 10-foot globe in our living room, and even one that size is absurdly small to represent the earth. Therefore, to be clear, only the most important features should be shown. It can then serve as an index to the maps of continents, and they, in turn, as indices to the maps of countries, and so on down to states, counties, areas, and towns. Maps should be used for detail, but it should be remembered that only a globe is a picture of the earth. If a globe and a map disagree, trust the globe. All maps should be in the form of sections of globes, but unfortunately this is not practical in the case of an atlas. As a map is flat, it is always a distortion. For small land areas it may seem to be more accurate than a detailed globe; for large areas it never is.

With a good globe and a piece of string it is possible to chart the route of ships and airplanes, for on any sphere the shortest line between two points follows the "great circle" (a circle whose center is coincident with the center of the sphere). Globes are often used to demonstrate the works of man—steamship routes or radio stations. Radio globes are particularly serviceable for anyone who owns a di-



GORES FOR A TERRESTRIAL GLOBE

Early globes were made individually and painted by hand. Since 1507, when Waldseemuller issued a 110-millimeter-diameter globe covered with printed segments or gores, this cheap and expeditious method has come into general use. It offers an easy way of correcting globes to keep up with changes wrought by wars. The illustration is reproduced from "Elements of Map Projection" by Charles H. Deetz and Oscar S. Adams, U. S. Coast and Geodetic Survey.

rectional set which operates better if its aerial is turned toward the transmitting station. That direction is not easy to find on ordinary maps; and maps distorted for this special purpose are so crazy in appearance that not even the outlines of continents are discernible. Another useful addition to the globe is the small circular hour disk, commonly placed around the North Pole, which can be rotated so that any meridian may serve as a reference line in determining the time in London, New York, or Samarkand without the mental gymnastics usually involved. Then there is the international date line. Like the hour disk it is of astronomical origin and, being a fixed part of our earth the same as hours, latitudes, longitudes, and zones, may be shown properly upon a globe.

Today, most men are more interested in mundane affairs than in the heavens, a fact the author has proved by trying to buy a celestial globe. Not one was to be found on sale in Denver, Colo., and so a manufacturer was ordered to make one equipped as follows:

> With a complete meridian circle and adjustable axis so that the globe's axis may be set parallel to the axis of the earth, for in that position only will it show the apparent motions of the stars as we might see them outside of our front door.
>
> An hour angle scale attached to the meridian circle at the elevated pole, and a calendar scale on the globe to be used in conjunction with it.
>
> A horizon line on the stand (this is usually provided with a form of cradle) so that all the stars may be visible above the horizon line at the moment for which the globe has been set, the horizon line preferably to be marked for east and west and graduated into degrees to give the bearings or azimuths.
>
> An altitude quadrant with a pointer to find simultaneously a star's altitude and its bearing on the horizon line.

On such a globe (and the one ordered came complete, except for the fourth requirement) can be found the "addresses" of the stars, the time of their rising and setting, and their altitudes and directions at any given moment.

Celestial globes are used regularly on board ship. One of the navigating officers calculates the approximate position from the speed and course of the vessel by what is known as "dead reckoning." He then sets his globe according to the calculated latitude, adjusts the hour angle and calendar scales agreeably to his estimate of the local time of the ship, and so sees the heavens as they are at the time when the round of sights is to be taken. Then he can easily find the approximate altitudes of the four stars required to make a good "fix" of the boat's position. But where it is going, and how it got where it is, are usually determined by a terrestrial globe before the voyage begins.

Just as globes have tempted mariners to fare forth in the past, so do they tempt them today. And if wanderlust obsesses you—if you are curious about distant lands where you would like to go but cannot—you may have a lot of fun with a globe and a piece of string charting the routes of ships and airplanes. For example, lay one end of your cord at New York and the other at Pekin. Follow the route, and you will find out why the Lindberghs flew *North to the Orient*. Experiments of this sort lead to great enterprises. With a globe and a piece of string, Juan Trippe, President of Pan American Airways, determines where the great clippers should fly. Uninhabited islands along the line of his string become well-provisioned stations; jungles, airports; and cities, centers of flights. Over the seas air currents are measured, prevailing winds charted, and, when all is ready, the international clippers fly in the line where a piece of string has lain against a globe.

If you have a terrestrial globe, or are planning to buy one, remember that it is earthy and that earthworms know nothing of ecliptics nor of the analemma set in the sea. If possible, get a celestial globe later, then you will own the earth and sky and may find more within the pair than was ever dreamt of in your philosophy.

Much of the information about old globes contained in this article was obtained from Edward Luther Stevenson's "Terrestrial and Celestial Globes."

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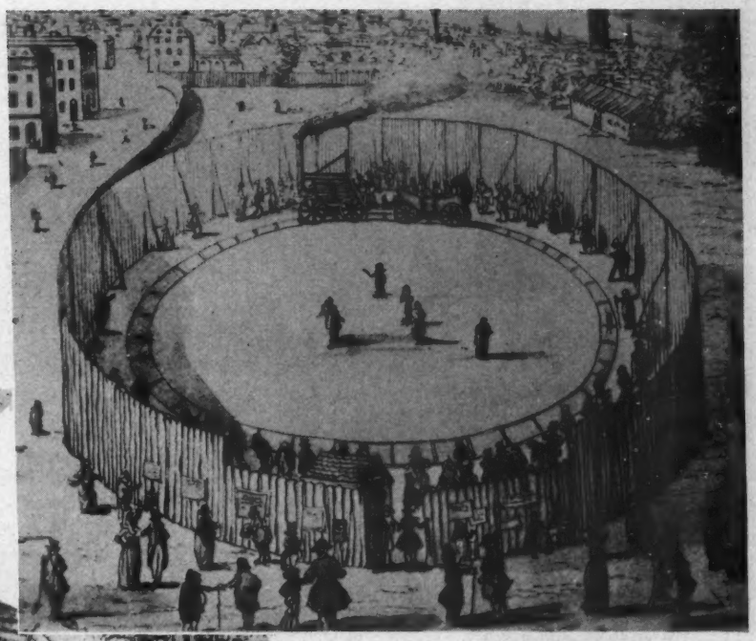
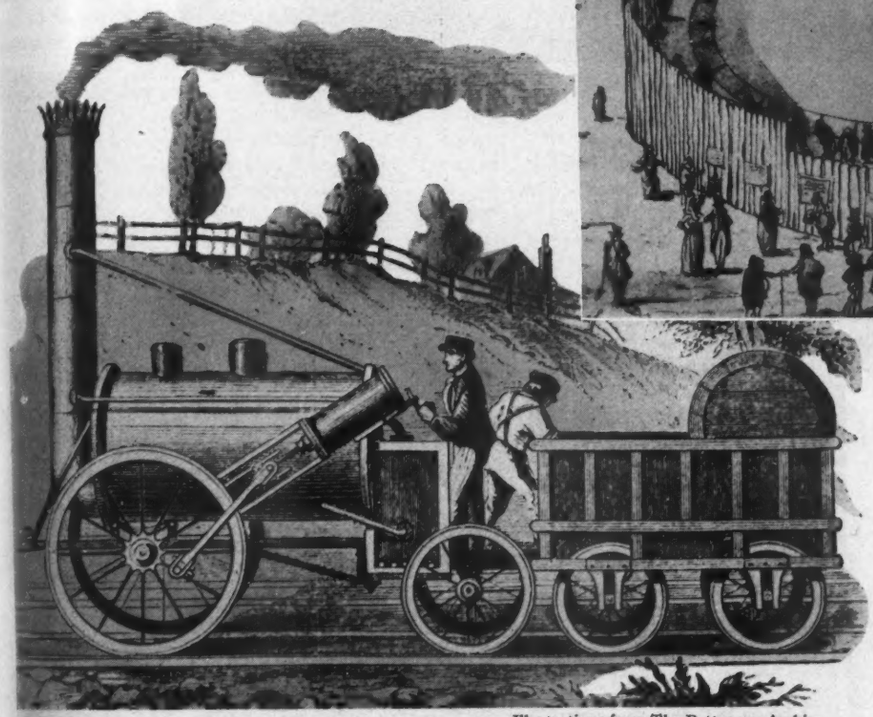
RENAISSANCE SCHOLAR AT WORK

During the Middle Ages the possession of a globe marked one as a person of learning and distinction, and most of the spheres were in the hands of map makers and astronomers. This illustration is a copy of an engraving by Stradanus-Galle.

Inventors and Some Inventions

H. W. Stowell





Illustrations from The Bettmann Archive

EARLY LOCOMOTIVES

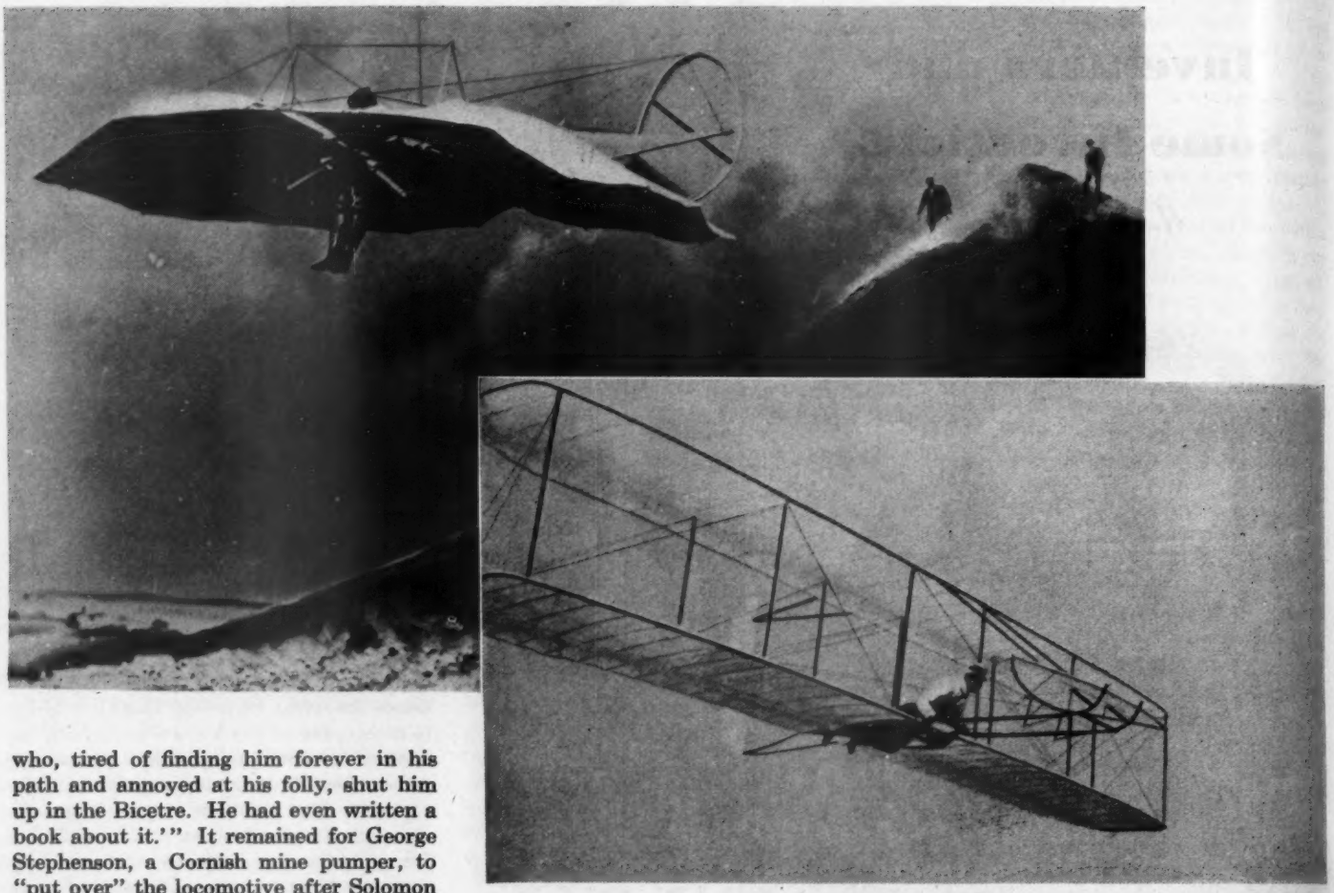
The first successful steam locomotive for heavy haulage was built in 1801 by Richard Trevithick, a Cornish mine captain. In 1808 he constructed near Euston Square, London, the circular railroad shown in the upper picture. It carried passengers at a rate of 12 to 15 miles an hour. George Stephenson was the first man to put the locomotive to extended practical service. His famous "Rocket" (above) won a 500-pound prize offered in 1829 by the Stockton & Darlington Railway Company for "the best locomotive engine." It drew a load of three times its weight at a speed of 12½ miles an hour. The "Rocket" weighed 9,500 pounds and used steam at 50 pounds pressure in a tubular boiler.

ALL inventions begin with a clearly perceived want or desire. Invention is a continuous process that goes on all the time. Inspirations that flash into the mind like a meteor, often considered an act of divine providence, are the result of the subconscious mind acting on material which the conscious mind has been mulling over. Chance no doubt plays an important part in discovery, but a chance hunch or lucky accident does not produce any reaction except when it comes into contact with a prepared mind. Opportunity must meet the right man, and the time must be propitious to receive the invention.

Some sad buried chapters in the history of invention tell how certain individuals were ahead of the times with their great inventions, which were adopted long after their deaths. An early genius who conceived a sewing machine carried it around on his back exhibiting it as a curiosity. Jacques Bessom invented a very ingenious screw-cutting mechanism, somewhat like a lathe, operated by ropes and pulleys. His device cut beautiful threads in wood, but civilization was not ready for his machine, and the screw-cutting lathe was invented quite independently by Henry Maudsley 150 years later. The wide gulf that existed between theory and practice from the days of the Egyptian-priest cults and the Greeks, and which, unfortunately, has not yet passed out of the picture even in this day of engineering and glorified mechanism, was a factor in retarding progress.

The steam engine was only a philosophical toy until it was taken in hand by Newcomen and Watt, practical workmen. While engaged in studying the problem of pumping water out of mines, Newcomen wrote the great physicist Hook (familiar to us because of Hook's law in physics) to learn if it would be possible to use the power of steam operating a piston to drive a pump. The physicist's opinion was, in effect, that it was "impractical." All but a few adventurous intellects, by accepting group tradition of a mass of opinions satisfactorily prearranged, find easy thinking. Unfortunately this is an obstacle to invention, and the tendency is to get in a rut. The bold spirits that do the pioneering often get the worst of it.

The locomotive was once the dream of a "mad" man. Solomon de Caus, confined as a lunatic in the Bicetre at Paris, had the right idea. Marion de Lorme, in a letter to the Marquis de Cinq-Mars, dated Paris, February, 1641, describes a visit to this asylum: "We were crossing the court, and I more dead than alive with fright, kept close to my companion's side, when a frightful face appeared behind some immense bars, and a hoarse voice exclaimed, 'I am not mad! I am not mad! I have made a discovery that would enrich the country that adopted it!' 'What has he discovered?' asked our guide. 'Oh!' answered the keeper, shrugging his shoulders, 'something trifling enough. It is the use of steam of boiling water.' I began to laugh. 'This man,' continued the keeper, 'is Solomon de Caus. He came from Normandy four years ago to present to the king a statement of the wonderful effects that would be produced by his invention. To listen to him you would imagine that you could navigate ships, move carriages, in fact there is no limit to the miracles he insists that could be performed. The cardinal sent the mad man away without listening to him. Solomon de Caus, far from being discouraged, followed the cardinal wherever he went with the most determined perseverance,



FIRST FLYING MACHINES

The glider was the stepping stone to the first airplane, and the foremost pioneer glider was Otto Lilienthal who, with his brother Gustav, started studying the flight of birds in 1867 as a basis for experimentation. In 1891 Otto built the first man-carrying glider, which had a peeled willow-rod frame covered with tough cotton fabric. In flying it he thrust his arms through padded rubber tubes and held on to a crossbar with his hands, his body hanging in the air. The upper picture shows Lilienthal on one of his initial flights from a hill he constructed near Berlin. He was killed in 1896 while attempting to better his previous longest glide of 350 yards. The Wright Brothers became interested in aviation through the reading of Lilienthal's work. After much study, in which they cast aside as faulty previously collected data and amassed their own, they developed a system of maintaining the equilibrium of a plane by varying the air pressure on different parts of the machine. This was done by adjusting the angles of the wings and auxiliary surfaces. This so-called aileron control was the basis of their success. The photograph directly above shows Orville Wright flying the first practical airplane at Kitty Hawk, N. C., in 1903.

who, tired of finding him forever in his path and annoyed at his folly, shut him up in the Bicetre. He had even written a book about it.'" It remained for George Stephenson, a Cornish mine pumper, to "put over" the locomotive after Solomon de Caus had been dead 200 years, and James Watt considered it impractical.

The long and involved story of the steam engine is a classic example of invention and well worth the study of anyone in mechanical or engineering pursuits. The piston and cylinder are part of our heritage from pre-Christian antiquity. Credit for the force pump, using these fundamentals, goes to Ctesibius, or Hero, Greeks of the Alexandrian school of about 200 B. C. Almost 2,000 years later (1705) Newcomen, an English blacksmith, had the happy thought of raising a piston with steam and then condensing the steam by cooling the cylinder. The upper end of the cylinder was left open, and atmospheric pressure on top of the piston gave a powerful down stroke. The power was applied to one end of a walking beam, and the other end of the beam was hitched to a reciprocating pump and used to drain mines and sometimes to supply water to water wheels, etc. Thus the first steam engine was born—really an atmospheric engine because atmospheric pressure performed the power stroke. The steam was delivered at little or no pressure, displaced the air under the piston, and by condensation formed a vacuum under the piston. Any sort of high-pressure boiler was beyond the capabilities of the workmen of that day, and probably not thought of before Watt's time.

A boy named Humphrey Potter, who operated the valves on a Newcomen engine in 1713, arranged a system of pegs, strings, catches, and beams to operate the valves automatically. This was improved in 1718 by Henry Beighton, who used a vertical beam with pegs called a plug tree, and so the first valve motion was born. What a long line of eccentrics, links, cams, push rods, and complicated mechanisms have descended from that homely device.

The next man, who was the inventor of the steam engine as we know it today, was James Watt. The famous teakettle story that relates how James, as a child, was impressed with the power of steam by watching it lift the kettle cover and dreamed of the giant slumbering within, is not accepted by his biographers. It is a good story, and was told by his aunt 50 years after the event is supposed to have occurred. Watt is not known to have mentioned it, and his attention was brought to the steam engine in quite a different manner when he undertook to repair a model of a Newcomen engine for the University of Glasgow, where he was employed as instrument maker. In attacking the problem of improving that inefficient engine Watt founded thermodynamics, and as a result of his own experiments learned that water, when boiled to the steaming point, generates 1,800 times its own volume of gas. He also learned of the property of latent heat through experimentation. Steam at 212°, he found, could heat six times its own weight of water to the boiling point.

Watt's own story of how the invention of the steam engine occurred after long study of the wasteful Newcomen engine and the discovery that it wasted three-

fourths of the heat, is as follows: "I had gone to take a walk on a fine Sabbath afternoon. I had entered the green and passed the old washing house. I was thinking of the engine at that time. I had gone as far as the herd's house when the idea came into my mind that as steam was an elastic body it would rush into a vacuum and that if a connection were made between the cylinder and an exhausted vessel steam would rush into it and might be condensed without cooling the cylinder. . . . . I had walked no further than the golf house when the whole thing was arranged in my mind." Thus the idea of a separate condenser was born.

Watt had in mind at that time a low-pressure engine operating with steam at a pressure little above that of the atmosphere. His patents also covered a high-pressure engine that might function non-condensing—that is, exhausting into the air. It is noteworthy that his invention occurred two years after his work on the engine. It is of interest to note that Watt's first partner went broke and that his second partner spent a fortune before the steam engine began to pay. Watt's advice to inventors was, "Hire yourself to some one as a ploughman—it will cure ennui." George Stephenson said: "Of all things in heaven and earth the greatest is the 'gift of gab.'"

More thrilling than a detective story is the history of inventions—how various ingenious minds attacked the problems of putting the forces of nature to work. They were solved a small step at a time, often by many minds attempting to answer the same problem—adding a little here and there—by an evolutionary process. The mechanical wonders of yesterday are taken as a matter of course today. Inventors experimented with locomotives from 1769 until 1829. It was then that Stephenson's *Rocket* established the success of steam railways and the engine began to take on the form so well known today. George Stephenson (1781-1848) helped his father fire a pumping engine in a mine and learned to read at the age of nineteen so he could study about improvements made in engines! He became interested in locomotives, and through practical experiment discovered that it took a force of 10 pounds to move a ton on a level track. Stephenson's early locomotives were little improvement over horses as a source of power until he invented the steam blast—that is, turned the exhaust steam up the chimney of his engine to increase the draft—and used a boiler in which a large heating surface was provided by many small tubes through which the hot gases passed. These advances contributed to the success of the *Rocket*, which outdistanced all competitors at the Rainhill trials. With the aid of a bucket of water and a rubber hose Stephenson ascertained how much vacuum the steam blast produced in the smoke box of the *Rocket*.

Locomotive "front ends" have been a sort of mystery and subject to scientific experiment ever since. Not until about 100 years after the day of the *Rocket* were the mysteries of the steam blast in that end thoroughly investigated and cleared up at the test plant of Purdue University. Spark arresters for locomotive front ends that trap cinders by netting, centrifugal action, or otherwise, are the subject of many patents and will be improved further.

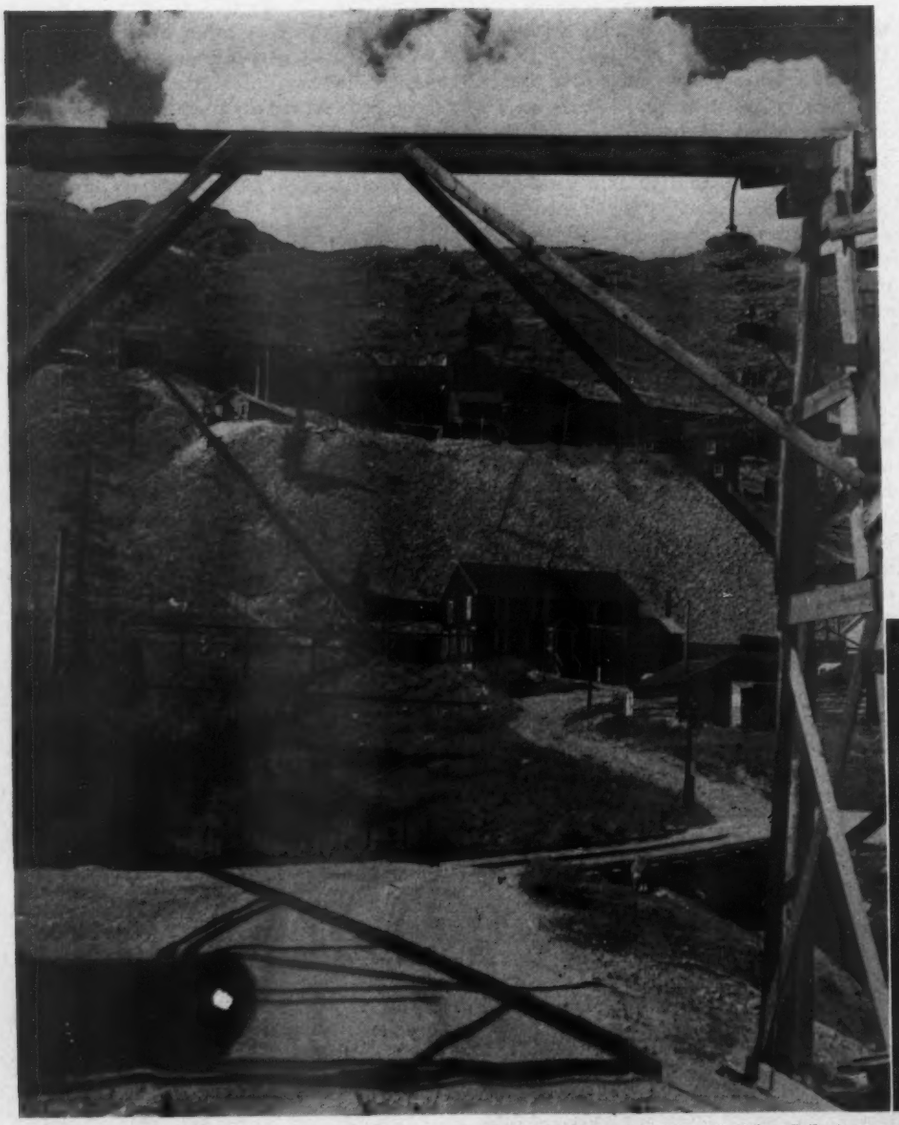
Stephenson deserves the greatest credit for making a successful locomotive, but curiously his name is perpetuated by an invention he did not make—Stephenson's "link motion" which was for many years the most popular valve motion on locomotives in England and America. This device was invented in 1843 by William Howe of Newcastle, England, and the idea was sold to Robert Stephenson who was then associated with his father, George Stephenson, in locomotive building. The price paid was equivalent to $105, and Stephenson patented it in his name. He subsequently embodied it in the *Rocket*, thus enabling the engine to be reversed quickly. Except for this device, practical men of today—locomotive engineers, machinists, etc.—would not know the name of Stephenson.

The romance of how man learned to fly is, of course, made up of the history of the inventions of aviation. It took a practical bicycle mechanic to fly some years after Professor Langley had built a plane that would have worked had man known how to get it into the air. Even in this day of careful scientific research chance plays an important part in discovery. Airplane-engine "wiggle weights" were the result of a lucky accident. It was observed that one radial-type motor ran much smoother than others, and upon investigation it was discovered that the counterbalance on the crankshaft had worked loose on its attaching bolts. This led to the invention of the flexible counterbalance held in place by stiff springs which cushion the shocks of compression and explosion and store energy something like a flywheel. Most large modern radial motors use this gadget.

At this time, when all industry is speeded up by a nation preparing for war, inventions of value can be turned into cash. These need not be of direct military value, as devices to improve transportation and to increase production are needed almost as much as better ways to annihilate the enemy.

JAMES WATT IN HIS LABORATORY

While working as a maker of mathematical instruments at the University of Glasgow, Watt became interested in the possibilities of improving the Newcomen steam engine, which was then applied only to pumping. His real opportunity came in 1764, when the University's museum gave him the task of repairing a model of the engine. Impressed by its enormous consumption of steam, he set about determining the cause and correcting it. The outgrowth of his researches is the modern condensing steam engine.



Photos by Thos. J. Barbre

Labor Shortage Puts Women to Work in Western Mine

THE shortage of labor is being keenly felt throughout the metal-mining areas of the western United States. It has already curtailed the production of some properties, and mine managers expect the situation to grow worse. Large numbers of miners have left the camps to enter the armed forces or to take jobs in war industries, to which they are attracted by better wages. Numerous mines have increased the daily rate of pay; but, with the prices of all essential metals pegged by the Government, wages cannot be raised to the level of those prevailing in the large industrial centers.

Mathew Murphy, Nevada State Inspector of Mines, stated recently that Nevada's output of vital war metals could be augmented by one-third if 2,000 additional miners could be procured. The shortage of skilled underground workers is so acute that one of the state's largest mining companies has started a training school. The situation is much the same in other mining states. The Hecla Mining Company of Wallace, Idaho, reports that its operating crew is 100 men below normal, but that it has so far been able to keep its mill running to capacity seven days a week. This has been accomplished by better organization of the crews and by obtaining more work per man in a given interval. The Coeur d'Alene District, in which the Hecla Mine is situated, is a leading producer of lead and zinc, and the U. S. Department of Labor has representatives there studying ways and means to keep the property operating at full capacity. The program outlined includes teaching inexperienced men to become specialists in each branch of the work, improving labor relations, and educating the miners to the need of greater individual production during the wartime emergency.

The plight of gold mines is especially acute, as gold does not contribute to the war effort. Gold producers are consequently on their own—that is, they cannot expect help from the Government and must solve their own labor and materials problems as best they can. Silver mines are in much the same position. One Colorado mine, the London Mines & Milling Company, has already started employing women, as the accompanying pictures prove. So far, seven have been put to work sorting ore, cleaning and oiling machinery, and doing other tasks that release men for actual mining operations. Supt. H. L. Tedrow hired the women as

an experiment and says that he is pleased with the results to date. It is necessary, of course, to train the feminine contingent, and this is done by experienced men. The women are quick to learn and exhibit great dexterity, which is of help to them on some of the jobs. One has shown such aptitude that she is being trained to operate a tramway hoist. All claim that they like the work, although this may be because it is decidedly different from anything they have previously done.

The London Mine is primarily a gold producer, but it yields some silver and lead. The concentrates produced in its mill also have an iron content that makes them useful for fluxing purposes in the smelting of other ores. The mine was opened in 1875 and has been operated almost continuously ever since. At various times it has been one of the leading sources of gold in Colorado.

FEMININE TOUCH IN THE HIGH ROCKIES

Seven women are "learning the ropes" at the London Mines & Milling Company near Alma, Colo., having taken jobs vacated by men. All are doing comparatively light tasks on the surface and are making out so well that additional members of their sex may be employed. There is never much floating labor in a metal-mining camp, and mine managers have found it impossible to hire men to fill the places of workers inducted into military service or lured into war industries by higher pay. The center picture shows three women being instructed in sorting ore by a veteran male employee of the London mill. The raw ore that comes out of the tunnel is dumped on to a conveyor belt, and the sorters pick out the worthless waste rock as it moves by them. Two of the women are married. Pictured above is Mrs. Doris Hill, aged 21, using a grease gun to lubricate the drive pulley of the conveyor belt. Her husband, Harvey Hill, left her and their year-old daughter to work as a carpenter on a Government project in Hawaii. The view on the opposite page was taken from the portal of the mine tunnel and shows the office building in the foreground and the mill on the hillside above it. The London property is located not far from Leadville in the Mosquito Range and at an altitude of 11,500 feet above sea level. It is primarily a gold producer, but yields other minerals that are of use in the war effort. This is the first time in the mine's 77 years of operation that women have been employed there.

Unusual Set-up for a Wagon Drill

DOWN BUT NOT OUT

The portable compressor that was caught in a slide and put back in service condition. It was badly battered, but sturdy construction warranted repairs.

WAGON drills are, as a rule, shifted from one operating position to another on their own wheels and are used to drive vertical holes and toe holes. However, there are always exceptions to every rule, and such was the case with the wagon drill that is shown in one of the accompanying illustrations. The machine was mounted on a motor truck so as to raise it and thus enable it to drill horizontal holes at points in hillsides that would otherwise have been beyond its reach.

The set-up was utilized in constructing an 8.15-mile road between Santa Fe and Taos that constitutes a link in New Mexico's Kit Carson Highway. The old route that connected these two points was a section of an old military road known locally as El Camino Militar and was built by U.S. Army Engineers in the last half of the nineteenth century. Like the latter, the new highway runs along the bottom of the canyon of the Rio Grande for a distance of 5 miles, and this stretch involved considerable side-hill cutting. In this section the river flows through a faulted area, and the rock system on the eastern side of the stream which the road follows was found to be badly seamed and shattered. This added to the drilling difficulties and multiplied the danger of slides.

To do the work of drilling expeditiously, the contractor—Henry Thygesen, Inc., of Albuquerque, N. Mex.—mounted his FM-2 wagon drill on a truck, as has already been mentioned, and in that way was able to put hole after hole in the steep hillsides and maintain the desired grade. Another advantage of this arrangement was even greater portability than the machine itself affords. The compressed air for the drill was furnished by an Ingersoll-Rand compressor that also was truck-mounted. This unit was caught in a slide, but it survived to prove its worth.

DOUBLY MOUNTED

This FM-2 wagon drill was mounted on a motor truck to give it an added lift so as to drive horizontal holes at a height beyond its normal reach. In this way the contractor was able to maintain road grade throughout a 5-mile canyon section characterized by steep slopes of talus or rock in place.

At one point in the line where the work of excavating and rock removal had been completed, and where only a little trimming remained to be done, the back slope suddenly began to move. Fortunately, the power shovel had been backed away, but the slide caught the compressor, almost completely burying it. Upon examination it was found to be pretty well but not hopelessly battered up. According to E. B. Bail, Materials Engineer of the New Mexico State Highway Department, it "was sent back to work after repairs totaling about one-eighth the cost of a new machine, a rugged testimonial to sound construction. Parts of the truck were found, but not enough to prevent its being listed as a casualty."

The entire project involved the placing of 3,600 cubic yards of concrete in 87 drainage structures, the building of one reinforced-concrete bridge (jobs that were done under a subcontract), and the excavating of 842,000 cubic yards of unclassified material. The contract stipulated that the job be finished in 200 working days, but it was actually concluded in 161 days despite the difficulties encountered. Laying the base course and surfacing the road was done under a separate contract that was also awarded to Henry Thygesen, Inc., and was carried out by the contractor in 45 instead of the specified 60 working days. The accompanying photographs are reproduced by courtesy of the New Mexico State Tourist Bureau.

Traveling Crews Paint Bridges

THE Division of Highways of the California Department of Public Works has systematized the work of sandblasting and painting highway bridges. Traveling crews outfitted with special equipment for the job operate throughout the year, and they have become so experienced that even the largest bridge-painting assignment is reduced to a routine task. Since their organization in 1930, the crews have sandblasted and painted more than a third of the 450 steel structures in the California State Highway System. Up to August of last year this work has involved the treatment of 11,125,000 square feet of surface and the use of 7,450 tons of sand and 17,100 gallons of paint.

The crew is made up of a superintendent, a foreman, a timekeeper, two structural-steel painters, and seven skilled laborers. Six of the latter operate sandblast and paint-spray guns, while the seventh does general work such as mixing paints, repairing hose and spray guns, and servicing compressors. Up to six local laborers are hired as watchmen, flagmen, etc. When structures having less than 20,000 square feet of surface are being treated a crew is divided into two units, while an entire group goes to work on each large bridge. The painting program for each year is laid out in advance, and operations in each section are scheduled so that they will be carried out during the most favorable season. This is important, as it has been found that costs are considerably influenced by weather conditions.

All equipment necessary for the smaller jobs is mounted on a truck and trailer. Headquarters are made in the nearest town or highway-maintenance station, and the outfit is moved to and from the working site daily. A 210-cfm. portable compressor is employed. Semistationary equipment is used on the larger structures. It is transported by truck and trailer units and set up for the duration of the work, a tent camp being established. The compressor plant consists of two 315-cfm. portable machines. These are blocked up to take the weight off their pneumatic tires and are leveled. One-inch air-delivery piping serves the single unit and 2-inch the 2-compressor set-up. The latter pipe comes in 20-foot lengths, with tees inserted between joints and unions every 200 feet to permit making hose connections close to all points of work and to facilitate replacement pipe sections.

Sandblasting and painting are done from catwalks and staging. These are built on the spot, as this is cheaper than hauling the bulky materials from place to place. Operations are so well organized that on a typical job, involving the use of the larger equipment, everything is in readiness to start work on the third day after the crew arrives at the site. Sandblasting is the most expensive item, averaging around nine cents a square foot. A metal-core nozzle is utilized, and its ¼-inch orifice will withstand about 100 hours of service before being worn to a point where it is 1/32 inch larger. A new nozzle handles approximately 1½ tons of sand in 8 hours, and when that consumption has been increased by 50 per cent the nozzle is replaced.

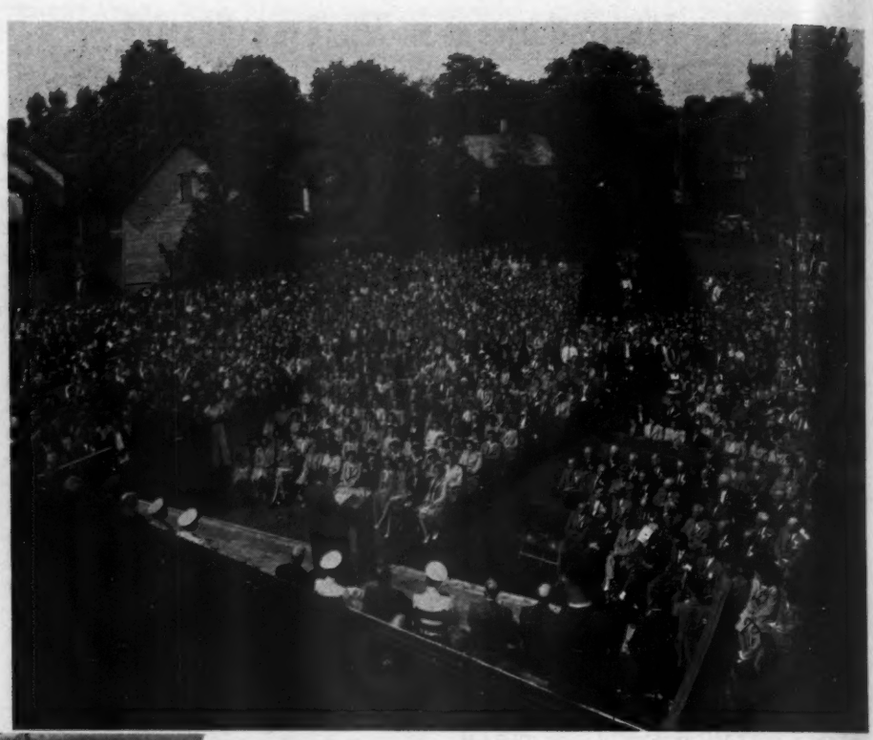
Sand of a specified size is purchased dried and sacked, as this has been found to cost less than bulk sand which has to be screened and dried. A "Y" connection at the outlet of each sand chamber permits one chamber tender to control two guns. A shut-off valve affixed to each sandblast nozzle enables the operator to stop the flow of sand without shutting off the air supply to the sand chamber.

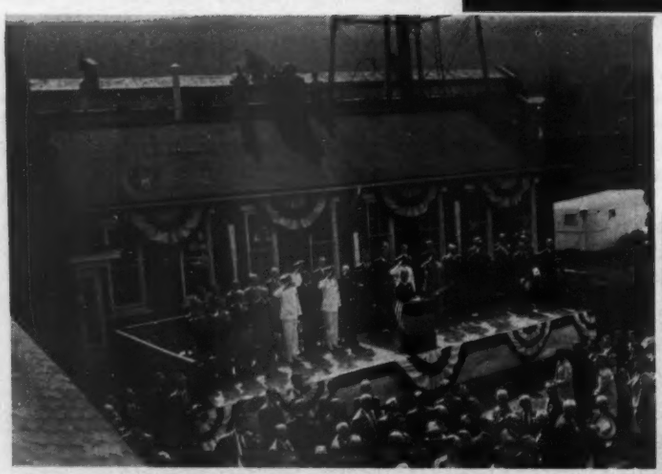
Sandblasting continues until bright metal is visible. Partly because of this thoroughness it is not possible to clean more than 80 to 120 square feet an hour, whereas a good painter will cover from 200 to 300 square feet in the same period. Because of this time differential, sandblasting is carried on six hours a day, after which the primer coat is applied. The final work of the shift consists of moving the staging at least three panels away in readiness for the following day's sandblasting. This is necessary to prevent the sand and dust from marring the previous day's painting.

Before the steel members below the deck of a bridge are sandblasted they are washed with a detergent, which is mixed with water and applied by air pressure through the medium of the sand chamber. This removes grime and dirt and often discloses considerable areas that are covered with sound paint. These are not sandblasted and are given only a finishing coat. Other sections of the steelwork receive a primer coat, a second coat, and a finishing coat. A 72-hour interval is allowed to elapse between applications. In addition to being the medium for carrying the sand, paint, and cleaning fluid, compressed air is used in agitating the paint. This work is done by the aid of an air motor that turns a 6-inch propeller mounted at the end of a shaft extending down through the cover of a standard paint container.

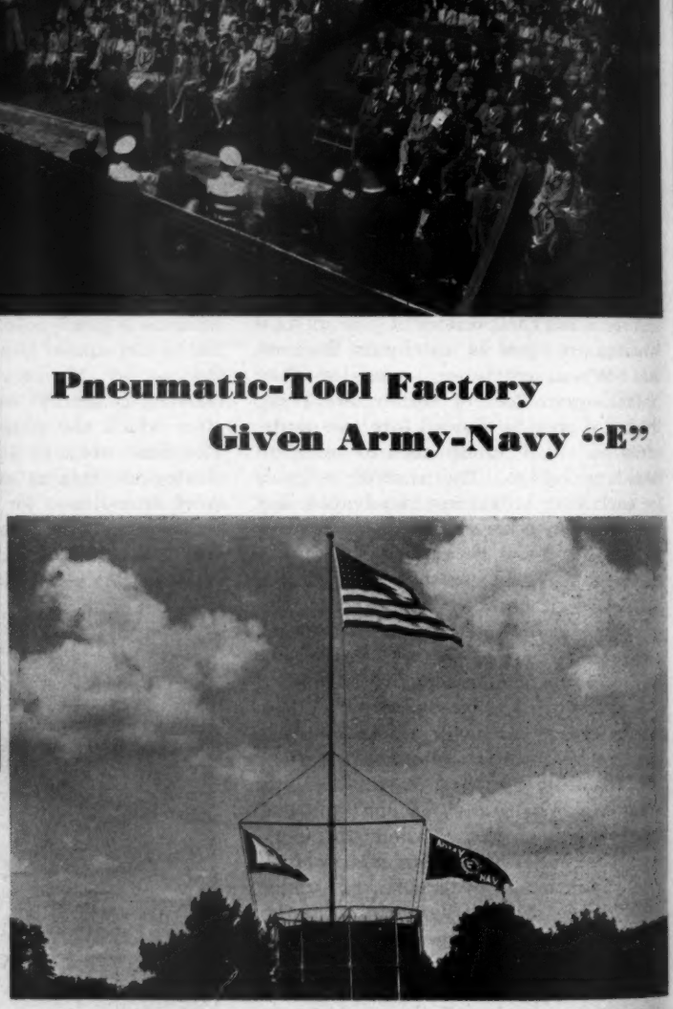
In the case of a typical bascule lift bridge 586 feet long and spanning a navigable river, 68,000 square feet of surface was sandblasted and given three coats of paint, while 10,000 additional feet was cleaned and given a coat of finishing paint. The cost per square foot was 9.09 cents for sandblasting, 7.98 cents for painting, and 1.57 cents for cleaning. Average unit costs for materials were: sand, $4.60 a ton; red-lead prime-coat paint, $2.65 a gallon; second-coat graphite paint, $1.75 a gallon; finish-coat graphite paint, $1.10 a gallon. A ton of sand cleaned 340 square feet, and the coverage per gallon of paint was as follows: first coat, 370 square feet; second coat, 450 square feet; finish coat, 340 square feet.

AIR COMPRESSORS, AND STAGING UNDERNEATH BRIDGE





Pneumatic-Tool Factory Given Army-Navy "E"



PRESENTATION VIEWS

The picture at the upper left shows Rear Admiral Bryson Bruce presenting the burgee to W. H. Jewell, general manager of the Athens factory. A view of the crowd is at the upper right. The shopmen, numbering more than 1,300, are standing at the left and in the rear. Directly above is pictured the speakers' platform with the dignitaries and guests standing at attention as the American flag is being raised. At the right is the 3-part mast flying the national emblem, the plant's service flag, and the "E" burgee.

THE Army-Navy "E," symbol of excellence and of high achievement in the production of war equipment, was presented to the Athens, Pa., factory of Ingersoll-Rand Company on August 24. The plant makes various types of pneumatic tools such as riveting and chipping hammers, grinders, drills, and impact wrenches, as well as air and electric hoists. Many of these tools are used by combat forces at the front, but to a far greater extent for the construction of ships, tanks, aircraft, and other mechanisms needed in war work.

The presentation of the "E" burgee was made by Rear Admiral Bryson Bruce, U.S.N., and it was accepted by W. H. Jewell, general manager of the Athens plant. The "E" lapel insignia was presented by Lieut. Commander Scott G. Lamb, U.S.N. (retired) to three employees of the factory whose years of service aggregate more than 100. This trio—Joseph P. LaPlant, Leonard N. Moore, and Leon P. Merithew—accepted the awards on behalf of their fellow workers. Later all those employees that were on the payroll on July 22, the date the award of the "E" was announced, received lapel buttons.

The ceremonies were held outdoors on the factory premises and were open to families of employees and to the public. Dr. Donald R.Guthrie of Sayre presided, and Burgess A. S. Buckley extended a welcome to the visitors on behalf of the town. Members of Fort Sullivan Post No. 246, American Legion, served as a color guard. Music was furnished by the Lehigh Valley Shops Band.

In addition to attaining the standard of performance that entitles it to fly the Army-Navy "E," the Athens plant has sent more than 100 of its personnel into the nation's armed forces.

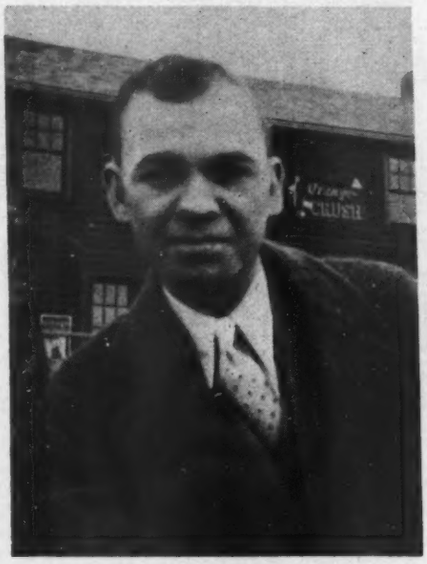
Compressed Air Institute Awards Contest Prizes

PRIZES aggregating $1,000 have been awarded fourteen men in the United States and Canada for papers describing applications of compressed air in industry. The awards were made by the Compressed Air Institute, a national association of 23 manufacturers of compressed-air equipment. The contest in which the papers were submitted ran during the first six months of the year and was conducted by the educational committee of the institute.

First prize of $200 went to A. W. Lancaster of Orillia, Canada, for a paper detailing how air-operated mechanisms increase the production of cartridge cases by approximately 500 per cent.

Three second prizes of $100 each were awarded to Irving G. Mayer of Phoenix, Ariz.; Lieut. Albert J. Nauta of Daniel Field, Augusta, Ga.; and Harold W. Martin of Belmont, Mass. Mayer's paper describes a method of surfacing roads and other structures with asphalt and stone with a compressed-air gun. Lieutenant Nauta wrote of a process for freeing water of iron by passing compressed air through it. Martin's paper deals with compressed-air circuit breakers for high-voltage electrical lines.

Ten third prizes of $50 each were also awarded. The recipients and the subjects on which they wrote are as follows:



A. W. LANCASTER
Recipient of first prize of $200

J. M. Weil of Phillipsburg, N. J., and Paul Hoffman of Easton, Pa.—Operating forge hammers with compressed air.

Vincent L. Greth of Lakewood, Ohio—Application of the Bernoulli principle in freeing metal plates from die blocks and speeding up the production of Precipitron air filters.

George C. Tucker of Barre, Vt.—Reducing the cost of compressed air through unique storage methods.

Frank D. Biesanz of Winona, Minn.—The use of a pneumatic gun for shooting coke screenings into brick kilns to heat all the brick evenly.

Joseph P. Burdett of Whittier, Calif.—An air-operated machine for mowing submarine plants in irrigation ditches.

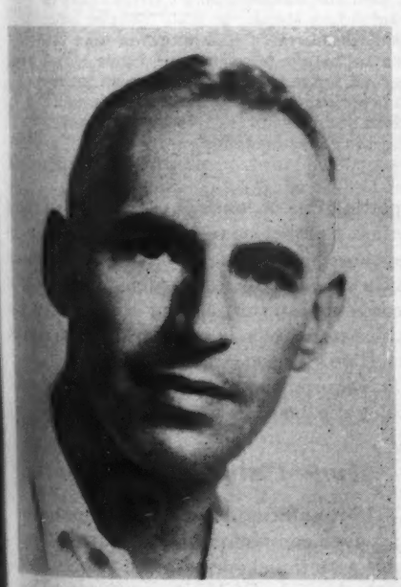
S. F. Shaw of San Antonio, Tex.—New methods of pumping oil wells by air- or gas-lift.

Stephen M. Dunham of West Orange, N. J.—The installation of vibrationless compressed-air machinery on the tenth floor of a loft building and the use of compressed air in manufacturing cosmetics.

Rex. T. Stafford of Pittsburgh, Pa.—The substitution of compressed air for oil in electrical transformers.

P. O. Enger of Houston, Tex.—A tool for vibrating poured concrete used in the manufacture of ships.

Maj. G. K. Saurwein of the Watertown, N. Y., Arsenal—The compressed-air distribution system at Harvard University.



IRVING G. MAYER

LIEUT. ALBERT J. NAUTA

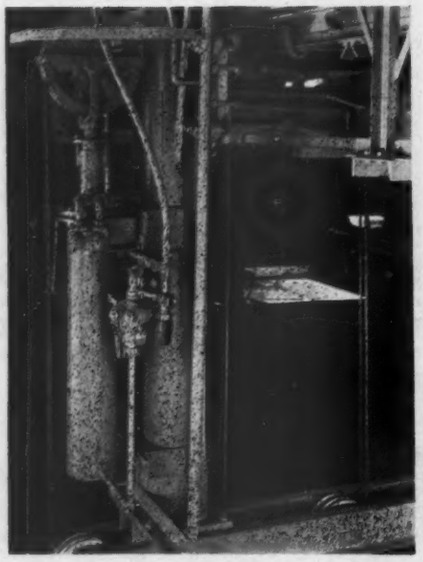
HAROLD W. MARTIN

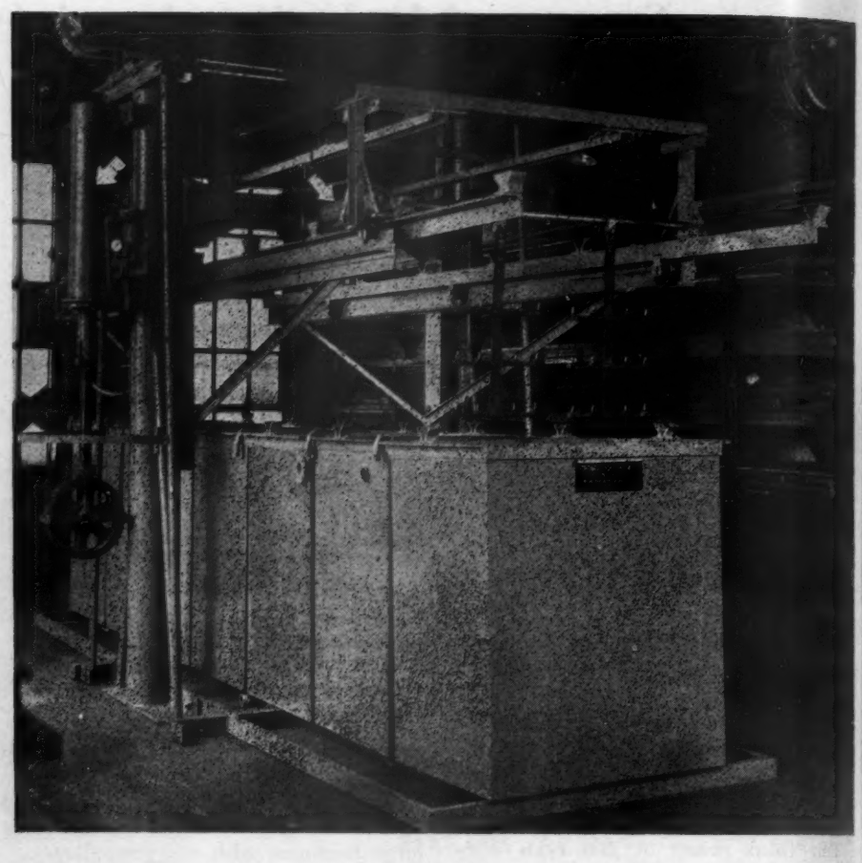
Air Transfer of Oil from Underground Storage

UNDERGROUND storage of lubricants and other medium-viscosity fluids in quantities of 1,000 gallons and more is becoming general practice in England. These are handled in two ways: by means of compressed air or by the use of a small booster pump driven by an electric or an air motor, the latter, or the direct-pressure method, being preferable where the presence of gases of an explosive nature constitutes a hazard.

The simplest method of transfer is that of applying compressed air to the free surface of the liquid. Air at 60 pounds pressure per square inch is generally used for this purpose and is supplied by a single-stage compressor or direct from a plant's main air line. Where different grades of oil are required the installation consists of a large tank separated into compartments each provided with its own distribution line; air, stop, and safety valves; pressure gauge; and float-operated indicator. Cost of maintenance with the direct-pressure method, especially where a plant is already piped for compressed air, is low.

Pneumatic Transfer Expedites Plating Operations





SERVES SEVEN TANKS

This Crown pick-up is arranged for l-way travel and automatically carries racks of work to be plated from the loading to the unloading stand. In their transfer from tank to tank, the racks are successively raised and lowered, the length of time the work remains in each tank being governed by means of a variable timer. The horizontal and vertical air cylinders that control forward and up-and-down movement are indicated by arrows. At the left is a close-up of the vertical pneumatic cylinder showing the valves and air connection and three of the five power sheaves through which the pick-up frame supporting the racks is shifted.

FOR use with semiautomatic plating equipment, the Crown Rheostat & Supply Company has developed a pneumatic pick-up for the purpose of simplifying and expediting the transfer of the work. The unit is operated automatically by two air cylinders—one disposed vertically and the other horizontally—which raise and lower a frame from which racks are suspended by means of a rod and control its longitudinal and transverse movements. The machine is provided with a variable timer so that the individual functions can be speeded up or slowed down at will; permits 2-way travel; and can, it is claimed, be adapted for a wide range of layouts.

Where the number of racks to be handled hourly is not large, the work may be carried by the pick-up through the cleaning tank, transferred manually to the plating tank, and then back to the pick-up for passage through the rinsing tank alongside the cleaning tank. For greater speed of operations, where movement in one direction is preferable, racks may be carried simultaneously through two tanks standing side by side each containing a different cleaning solution; transferred manually to one or other of several plating tanks; and then conveyed to and from the subsequent finishing stations by chain conveyor.

One set-up now in service has three Crown pick-ups at different points in an 87-foot line made up of five plating units. They raise and lower racks in groups of four and assist in carrying them through six copper-cleaning tanks, two copper-plating tanks, four rinse tanks, two nickel-plating tanks, and two rinse tanks. In this case the pick-ups are equipped with long arms which overlap the neighboring tanks so that the work can be transferred automatically from one to the other. This is effected through a series of air valves, as follows:

When a rod with a load of racks has reached the end of the copper-cleaning unit—the span of the first pick-up—it strikes an air valve, causing the vertical pneumatic cylinder to lift the frame and racks clear of the tank. At the limit of its upward travel the frame actuates a second valve which, in turn, operates the horizontal air cylinder, thus moving the frame forward to a point where it comes in contact with a third valve. This again brings the vertical cylinder into action, lowering the frame and depositing the work in the two copper-plating tanks arranged one alongside the other. From there on the racks are moved automatically to the next pick-up position by a conveyor chain and rails consisting of bus bars on which the ends of the rod rest.

Transfer throughout the length of the plating line is continuous, one set of racks after another traveling from station to station. From the time the first pick-up lifts a rod with its burden from a chain conveyor at the loading stand until the third unit unloads the work at the end of the line a period of 41 minutes has elapsed. The equipment handles 270 racks of zinc-alloy die castings an hour.

Huge Paint-Spray Booth

FOR painting large airplane parts and even complete bombers, there is available a sectional spray booth that is set up with the aid of folding partitions. There are eight sections which can be used as one huge compartment or in groups of two, three, or four, depending on requirements. When all are assembled they form a booth 152 feet long, 100 feet deep, and 31 feet high, with 15,000 square feet of floor space, or sufficient to accommodate a large-size bomber. To remove fumes and spattering paint, each section is provided with two ventilating fans which have a combined capacity of 62,000 cfm. and draw the air through a wash-down curtain 20 feet high and cascading water at the rate of 400 gpm.

Three-Dimensional Seeing

ALMOST unbelievable progress has been made in the past decade in providing better illumination in homes and factories. As recently as 1922 investigators of working conditions in England established minimum acceptable values of lighting for workshops: 4 foot-candles for fine work and 5 foot-candles for very fine work. Nowadays the acceptable standard in the United States is several times these figures, and many plants have raised the general illumination level to 40 or 50 foot-candles, and even provide 100 or more for fine work.

Today it is recognized that adequate lighting is not only beneficial to public health but that it also more than pays for itself through increased production, better workmanship, and fewer lost-time accidents. Greater attention to the hygienic side of the question began to be manifested about twenty years ago. An international congress for the study of industrial hygiene met in Geneva in 1924 and passed a special resolution that gave good illumination equal importance with heating, ventilation, and sanitary conditions in the matter of health and safety.

The development of the mercury lamp gave man a means of approximating daylight so that such delicate operations as matching colors can be carried out with accuracy even in windowless plants. In many industrial establishments better lighting has greatly reduced the percentage of rejects because of faulty workmanship and has enabled workmen and inspectors to increase their daily quotas and to finish their shifts feeling less tired than formerly. The latest contribution to better vision in factories is the so-called "3-dimensional seeing." It depends not alone upon light but also upon the use of suitable colors to make the work stand out. The light makes it possible to see clearly and quickly, while different colors produce contrast. The combination of the two gives a 3-dimensional effect.

The possibility of improving seeing conditions by color separation is the outgrowth of various crude experiments. One of the first recorded cases of the kind was in a shoe factory, where a workman persistently complained of headaches and blind spots. In seeking an explanation, the foreman noticed that he was working on black shoes at a finishing machine painted black. There was no contrast, and it was difficult to distinguish between the material and the machine. Sensing that that was the cause of the trouble, the foreman told the man to go to the paint shop and select a color pleasing to him, then clean and coat his machine. This had the desired effect, and it wasn't long until other operators tried the same thing. Each chose a color to his liking, and soon the shop looked as though it had been daubed up by a painter on a spree. However, the injury rate fell off by nearly 70 per cent, output increased, fatigue was less pronounced, and "seconds" declined.

Since that time there has been considerable scientific research in the field of illumination, with the result that certain standards have been set. One of the pioneer students was Arthur A. Brainerd, director of lighting service at the Philadelphia Electric Company. He concluded that dingy surroundings nullified the effect of intensified illumination and began experimenting with different colors in the company's offices. He found that a buff ceiling with an eggshell finish and buff or light-green side walls bettered visual conditions.

Mr. Brainerd and his staff next turned their attention to the machine shop of one of the utility's customers. The place was well lighted, but the machines were all painted in dark colors that blended into a dingy mass. A check-up revealed that accidents were fairly frequent, that the workers suffered from eyestrain, and that the rate of production was low. A number of machines were painted, each with a different light color, and the effects were observed. All proved to be more satisfactory than those coated with dark paint; but photometric measurements of the light reflected by them showed that buff was the best, followed in order by light gray, aluminum, and green.

Going a step further, the body of a machine was painted a different color than the immediate working area, choosing a medium gray. This color separation spotlighted the working zone without setting up too sharp a contrast to offend the eye. Time studies were then conducted, using different color combinations under both mercury and incandescent lights. The reactions of the operators also were recorded. The most effective combination was found to be the one that, according to controlled tests, had the best reflecting qualities—that is, buff for the working area and medium gray for the body.

In summarizing this phase of the investigations, the experts pointed out that "the chief feature of this color treatment is the 3-dimensional effect obtained by controlled color contrasts. The work in machines so treated stands out sharply in stereoscopic clearness that cannot be achieved by brightness contrasts alone." From the machines, they passed to the walls and ceiling, seeking colors that would be pleasing and nondistracting without "stealing" light. Here, too, light-colored paints proved to be the best.

The results of all the tests were placed before the Illuminating Engineering Society last fall. Since then the new 3-dimensional color scheme has been introduced in numerous factories. According to an article in *Domestic Commerce Weekly* by Corrie Cloyes, this face-lighting program has turned out to be a cheap investment in every reported case. Workers see more quickly and more surely than before, production has been stepped up, personal-injury hazards have been reduced, working conditions are better, and labor relations are consequently improved. In view of the demand for increased production of war matériel, this development is of great current importance. Under existing conditions its application is limited, but illuminating engineers believe that the idea will receive widespread attention when the war is over.

Log of Our War Economy

THE following paragraphs contain significant bits of information culled from official press releases sent out by the War Production Board.

SEPTEMBER 4—Quotas established in the campaign to collect 500,000,000 pounds of waste fat per year are 4.5 pounds per city dweller and 2.8 pounds for each rural resident. The latter figure is lower because fat is ordinarily used for soap-making and other purposes in farming areas. The quotas are considered conservative, as actual collections of fat in army camps have averaged 2 pounds per month per man.

SEPTEMBER 7—All governmental agencies have been invited to make use of the facilities of the Bureau of Reclamation's experimental laboratories in Denver, Colo., when they have engineering problems that need to be solved. The laboratory staff includes specialists in all branches of engineering that have had wide experience in designing and constructing notable irrigation and power dams in the West.

SEPTEMBER 6—To prevent manufacturers from debasing the quality of goods and selling them at the maximum fixed price for standard products of the same kind, the OPA is setting up a standards division. Specifications will be drawn up for all rationed commodities, and manufacturers may be required to attach labels that will indicate the use of inferior materials and any deviation from normal measurements and workmanship. In areas where rents are under OPA regulation, the nature and extent of the facilities that tenants are to receive for their rentals will be defined.

The automotive industry is now employing more than 800,000 persons and nearly all the facilities are devoted to war work. The peak is expected to reach 1,400,000 employees, or 40 per cent more than the present enrollment.

The War Manpower Commission issued recommendations that doctors engaged in certain kinds of public-health work be considered unavailable for military duty, the purpose being to insure civilian health with adequate safeguards. It was suggested that physicians in public-health service in classifications other than those marked for exemption and under 37 years of age be released for military service and that their places be filled by older men.

SEPTEMBER 8—Donald M. Nelson approved vacations for Jewish war workers on their religious holidays in September but suggested that they endeavor to find some way of making up the time lost.

The War Manpower Commission declared twelve western states to be a "critical labor area," and took steps to prevent the withdrawal of workers engaged in the production of copper and other non-ferrous metals, as well as of lumber. This course is deemed necessary to bolster the output of lumber, copper, aluminum and other products of the ground. There is current need for 6,700 additional workers in the copper-mining industry, which showed a net loss of 600 employees in the 4-month period ending July 15. This is the first "critical area" to be established in the country.

War Production Drive headquarters has awarded certificates to 33 workers in manufacturing plants for their suggestions to speed up operations. These individuals were singled out from among 12,000 that were recommended by committees in 1,300 factories employing 3,000,000 persons. Single suggestions have resulted in the saving of as many as 3,000 man-hours a year on certain work.

Four orders were issued curtailing the use of steel, copper, lead, tin, nickel and other vital materials by telephone companies. Included in the regulations is a ban on any more telephone extensions in residences.

SEPTEMBER 9—The campaign to uncover idle copper in excess inventories and divert it to war uses has so far turned up 55,000 tons of the metal and its alloys held by 14,000 firms. It is being allocated to war production at the rate of some 2,000 tons a week.

SEPTEMBER 10—By substituting electrolytic tin plate and bonderized black plate for the hot-dipped tin plate now used, it is expected that the tin consumed in the manufacture of cans will be reduced by 21,000 tons in 1943. Prior to the war, 1.5 pounds of tin was required to coat 100 pounds of plate. Under the new program only about 5 per cent of the packaged goods will receive that measure of protection. Some lines will be packed in glass instead of cans, but this involves the use of large amounts of vital materials and will be done only where pronounced savings in tin will be effected.

The estimated steel-ingot output of the nation for 1942 is 86,000,000 tons. Nearly 30 per cent of this goes back into furnaces in the form of scrap, leaving a monthly average of about 5,300,000 tons of finished products such as shapes, sheets, bars, pipe, wire, rails, etc. More than 75 per cent of these will be for direct war use and the remainder will enter into essential industries such as railroads, machinery manufacturing plants, and the like. The facilities for ingot production are being steadily increased and will probably reach 98,000,000 tons by the middle of 1943.

American resourcefulness has speeded up some munitions manufacturing operations to a degree that exceeds the fondest hopes of a few months ago. For example, the rifling of gun barrels is now being done in one-thirtieth the time formerly required.

Changes in specifications applying to all structural-steel buildings erected, financed, or approved by governmental agencies are expected to save 10 per cent of the steel heretofore used for the purpose. A manual is being prepared, and the new specifications will effect all contracts placed after November 9.

SEPTEMBER 12—Twenty-eight standard glass containers have been adopted for packing food products, and schedules setting forth which ones are to be used for specific products will be issued as promptly as possible. The containers range in capacity from approximately ¼ pint to 1 gallon, and the quantity of glass entering into the manufacture of each is fixed. Previous orders have established standard sizes for distilled and malt beverages, and the present one specifies five sizes for wines, preserves, and jellies. The regulations do not apply to home canners nor to commercial establishments that pack less than 1,000 pounds of preserves and jellies annually.

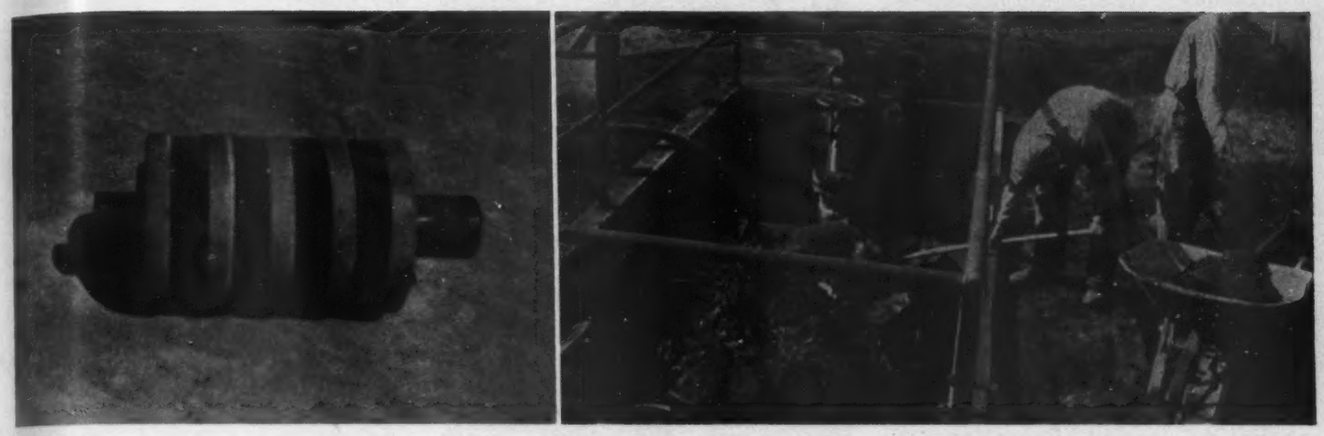
SEPTEMBER 14—A directive issued by the War Manpower Commission provides for the transfer of Government civilian employees to another department or agency, or to a private enterprise, if the Civil Service Commission finds that such a change will enable the employee to make a more effective contribution to the war effort. The directive supplements an executive order by the President and affects 2,300,000 civilian Federal employees.

The use of new or second-hand steel drums for shipping approximately 200 food, chemical, and petroleum products has been prohibited, effective 60 days from date. The packing of an additional list of 35 commodities is limited to steel containers already in the hands of packers. These orders are expected to save 100,000 tons of steel annually and to release thousands of drums for essential purposes. Most of the products barred from using drums will be packed in wooden barrels and in fiber and glass containers.

SEPTEMBER 15—Fuel-oil rationing in seventeen Atlantic seaboard states will be started during the next few weeks. It will be necessary to reduce consumption by probably 25 per cent of normal. Those who convert oil burners to the burning of coal were assured of an adequate supply of fuel.

SEPTEMBER 16—The railroad line from Boise City, Okla., to Farley, N. Mex., will be dismantled and its 980,000 feet of track utilized in naval bases and at a new arsenal at McAllister, Okla.

Air-Impelled Go-Devil For Pipe Lines

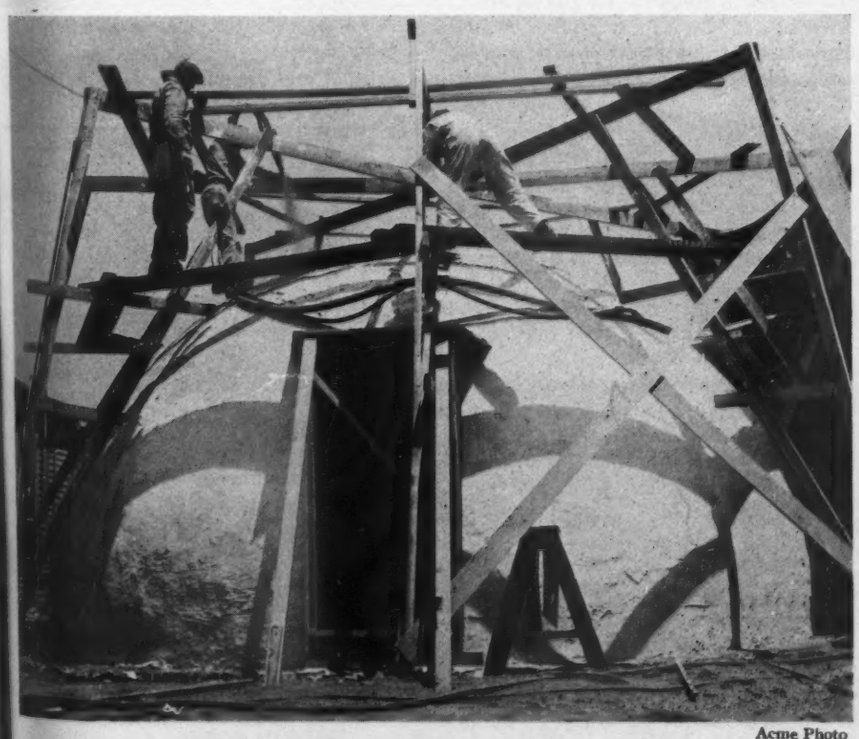


GO-DEVIL AND END OF SECTION

At the right is a gate valve showing men shoveling out sludge removed from a pipe by the unit at the left. As it is pushed through by high-pressure air the brushes and washers scour and scrape the deposited material from the walls.

ONE of the maintenance problems of operators of oil, gas, or similar pipe lines is that of removing the inevitable sludge that is deposited on the inside walls, restricting the passageway and possibly proving a contaminant. For this work The Osborn Manufacturing Company has developed a new type of go-devil that is introduced at a point slightly ahead of a gate valve and forced through the pipe to the succeeding gate valve under high-pressure air. The unit consists of a series of wire brushes separated by rubberlike disks, all held in place by flanges on a cylindrical fixture. The washers are beveled, the diameter of one edge being slightly larger than the inside diameter of the pipe so as to form an air-tight seal.

With the go-devil in position, the gate valve is closed, the pipe is capped, and compressed air is admitted, building up pressure back of it and shoving it forward, together with the sludge removed from the surfaces under the combined cutting and scraping action of the brushes and washers. The work is done in sections 1 or 2 miles long, depending upon the distance between gate valves, and the rate of travel is said to be from 3 to 4 miles an hour.



Acme Photo

BOMB SHELTER BUILT AROUND AIR BUBBLE

Last winter a contractor built a number of homes in Washington, D.C., by inflating a rubber balloon with air, sheathing the outside surface with wire mesh, covering it with a parting compound, inserting frames for doors and windows, and then applying concrete to the mesh by the "Gunite" method. The concrete shell so formed next received layers of asphalt, ground wood-pulp insulation, concrete, and paint. By connecting two such hemispheres by means of an intermediate room of conventional construction, houses were put up quickly and at low cost. In California the same scheme is being followed in erecting bomb shelters, but because of the scarcity of rubber a cotton balloon is employed. Following inflation, it is coated successively with asphalt, gypsum, balsam wool, and "Gunite." Shelters built in this manner will afford protection from flying fragments but are not designed to resist the impact of direct bomb hits. Our picture shows a workman applying "Gunite" with compressed air to one of these structures.

Substitute for Tin Cans

A NOTE of optimism has been sounded in the can-making industry through the announcement by the American Can Company that it has developed a process by which paper containers can be made on regulation metal-can machines. With priorities on the one hand and pure-food laws on the other, dealers in dry products heretofore packed in tins have been in a quandary as to how to market their goods in accordance with requirements and with the least possible change in the appearance of the packages. It is claimed that the new method solves all these vexing problems without the need of new machines for either manufacturing or packaging. This fact makes the process practicable today when mechanical equipment and tools are allocated only to war industries.

By the procedure, fiber sheets are run through the various tin-can lines, presses, etc., to cut the material to size, lithograph it, shear it, form it into bodies, and seam on the black-plate ends. The new container will look much like the familiar tin and will be made available to the entire can-making industry for the duration.

Industrial Notes

According to *Foreign Commerce Weekly*, Italy is operating motor-driven locomotives on a line in the Province of Venice with methane gas and at a speed of 60 miles an hour. The fuel carried is compressed, and gives the engines a radius of 300 miles.

An improved type of electric-cord retriever—the Cordomatic—has been announced by the Vacuum Cleaner Corporation. The reel is made in two sizes— 5½ and 7 inches in diameter and about 2 inches thick—and takes 10 and 25 feet of No. 18-2 SV. cord, respectively.

For men exposed at work to acids, caustics, etc., the Cadet Creme Company has added a waterproof cream to its line of skin-protecting preparations. It can be applied safely to hands, arms, and face, and is said to be impervious to a 20 per cent solution of sulphuric acid.

To conserve aluminum, the Logan Engineering Company is molding the rotors of its Aridifier air or gas cleaner of phenolic resin. It is interesting to note that tests have proved the substitute material to be superior to metal. The result is said to be less inertia and, consequently, greater efficiency, and the plastic rotors do not require balancing after machining.

The new safety helmet shown here is designed to shield the wearer against flying particles and to protect him against heat and hazardous fumes and gases. For the latter purpose the headdress is hooked up with a compressed-air line by a flexible hose which feeds a metal tube that is

curved to fit the forehead and provided with 24 vents. Impinging against the vizor, the air escapes around the edges of the face shield with sufficient pressure to prevent the outlying air from entering. Interposed in the air line is a filter to assure the worker a flow of clean air. The unit is equipped with an air-reducing valve, and a quick-brake coupling enables the wearer to break the air connection and to shut off the supply. The Kool-Air Faceshield can be adjusted to fit any head size and the vizor can be raised when not required.

For washing bearings for periodic inspection and for repacking them with fresh grease, Ahlberg Bearing Company has developed two portable units suitable for handling the full range of bearing sizes. Cleaning is done in a sealed compartment, and compressed air is used to dry the bearings before they go to the relubricator. The base of this device contains 5 pounds of grease, which is forced through the bearings placed above it by pressing down on a lever. It is claimed that the work is done quickly without waste and mess.

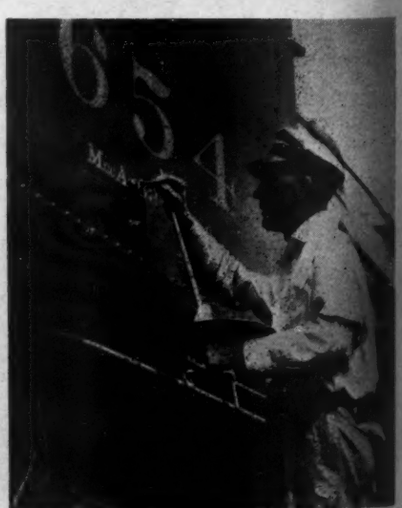
Chemical Solvent Company has announced an improvement in its line of Polarizers for treating boiler water. The unit is made of different metals and acts like an electrochemical cell upon immersion in the water, setting up a slight electrical field. It is claimed that scale-forming matter entering the field is converted into a precipitate that settles to the bottom for removal by blowing down. There are four types and sizes for fire- and water-tube boilers. They are said to be self-cleaning and to require no maintenance other than periodic metal replacement.

Wire and all kinds of fiber rope can, it is claimed, be given added service life by protecting them with a combination lubricant and preservative placed on the market in Canada by the Conneaut Packing Company. According to the maker, the compound penetrates the cable or hawser and covers each strand or fiber. In the case of wire rope it acts as a rustproofing and prevents binding and locking; in the case of hemp, manila, etc., it serves as a waterproofing, increases flexibility, lessens sheave friction and fiber breakage, and prevents dry rot.

Six NE—National Emergency—alloys have been developed by the metallurgical staff of the War Production Board to serve as alternates for nickel, chromium, vanadium, and other critical alloys. The new steels contain a minimum of these metals and can be obtained in small quantities from Joseph T. Ryerson & Son, Inc., for specific test purposes. They are available in hot-rolled rounds from ½ to 7 inches in diameter, and include two carburizing alloys, two medium-hardening alloys, and two high-hardening steels. The experts believe that these alloys, if properly selected and heat treated, will be satisfactory substitutes for steels with a high alloy content, except in cases of very special applications. As specific data on the behavior of the new alloys is lacking, users are requested to report details of various operations such as forging, machining, heat-treatment response, tool life, as well as results of any other tests, so that the facts can be made generally available.

RUSTPROOFING METAL STAMPINGS

This picture shows two of a series of six tanks used by the Bettcher Manufacturing Company to clean and rustproof metal stampings. The work is suspended from a rack, which is successively lowered into the solutions. In each of four of the tanks are three General Electric 4,000-watt, 230-volt Calrod immersion heaters which serve to heat the contents, while the solutions in all six are agitated with compressed air. Each tank holds 95 gallons.



FROM "MK" TO "MacA"

In 1897 the Baldwin Locomotive Works of Philadelphia built a new type of locomotive for the Japanese Government and designated it the "Mikado." The units proved to have such good pulling power that they were adopted in large numbers by American railroads, and many of them are in service today. After the Pearl Harbor attack the abbreviation "MK" on the sides of the engines became offensive to many railroadmen. The Central Railroad of Georgia initiated a movement to rechristen the class the "MacArthur." Painters got busy and "MacA" now appears where "MK" used to be.

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